THE UNIVERSITY *of* EDINBURGH

SOME ASPECTS OF FERTILITY AND MORTALITY IN SCOTLAND FROM 1855 TO 1943, WITH SPECIAL REFERENCE TO URBAN AND RURAL ENVIRONMENT.

By

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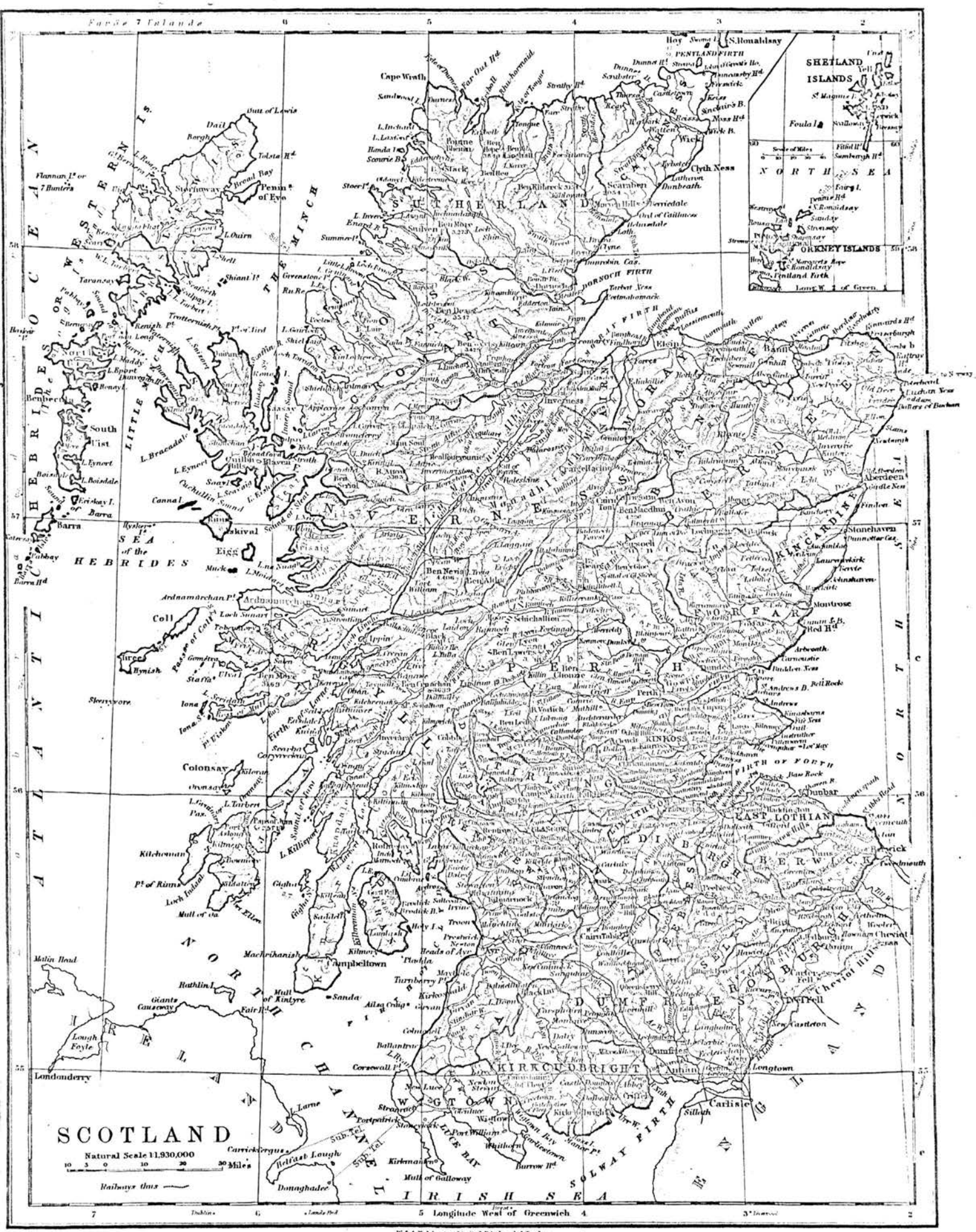

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C O N T E N T S.

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Table C./

CHAPTER I.

INTRODUCTORY.

1. THE TRENDS OF THE BIRTH-RATES AND DEATH-RATES IN SCOTLAND, ENGLAND AND WALES, AND SWEDEN.

The population of any one country is composed of sections which differ widely in their social and economic circumstances. It would be of interest to examine the changes which have occurred in the fertility and mortality rates of a few limited and approximately homogeneous groups, in order to find out what irregularities such simple aggregates present, and also to compare one group with another. However, the data available in the published reports of registrars-general and departments of vital statistics are generally not sufficiently detailed to allow of an investigation of this kind being undertaken. Nevertheless, it happens there is one major division of the population in respect of which the published Scottish figures permit an analysis to be made. This is the division of the whole area into geographical groups of towns of different sizes on the one hand, and country districts on the other.

The contrasting conditions prevalent in these different sections of the community make such an analysis of special significance at the present time, when concern is being felt about the decline of the population which will take place in this country in the near future, in consequence of the long-continued downward trend of the birth-rate.

During recent decades the vital statistics of the more developed countries of the world have exhibited two outstanding features: the first is a decline in the death-rate, and the second a similar decline in the birth-rate, the latter setting in some time after the former. It is generally realised that, for an adequate study of the changes involved, it is necessary, not merely to consider the crude birth and death-rates - that is, the number of births and deaths respectively per 1000 inhabitants - but also to take into account the age and sex distribution of the population. However, with the object of placing the more recent changes in fertility and mortality in their proper perspective, a table and a diagram have been prepared, showing the crude birth-rates and death-rates in Scotland, England and Wales, and Sweden, extending as far back as official records are available.

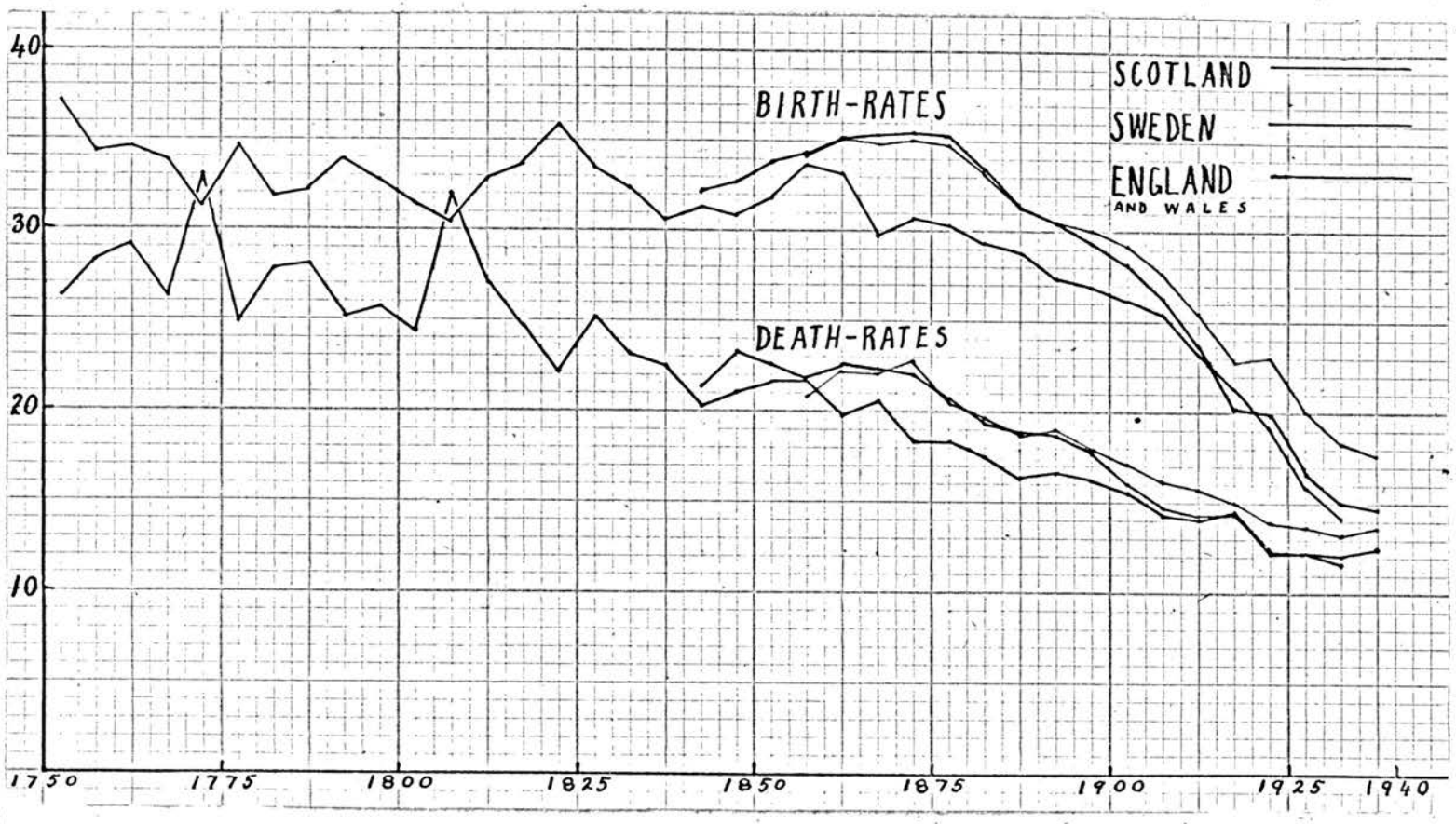


Diagram 1: Crude Birth-Rates and Death-Rates (Annual Births and Deaths respectively per 1000 Total Inhabitants), Sweden, England and Wales, and Scotland.

1751-55	37.1			26.3		
1756-60	34.3			28.2		
1761-65	34.6			29.0		
1766-70	33.8			26.2		
1771-75	31.3			33.0		
1776-80	34.7			24.9		
1781-85	31.8			27.8		
1786-90	32.1			28.0		
1791-95	33.9			25.1		
1796-00	32.8			25.7		
1801-05	31.4			24.4		
1806-10	30.4			32.0		
1811-15	32.9			27.0		
1816-20	33.7			24.6		
1821-25	35.8			22.1		
1826-30	33.5			25.1		
1831-35	32.4			23.1		
1836-40	30.6			22.5		
1841-45	31.3	32.3		20.2	21.4	
1846-50	30.9	32.8		21.0	23.3	
1851-55	31.8	33.9		21.7	22.7	
1856-60	33.7	34.4	34.1[a]	21.7	21.8	20.8
1861-65	33.2	35.1	35.1	19.8	22.6	22.1
1866-70	29.7	35.3	34.9	20.5	22.4	22.0
1871-75	30.7	35.5	35.0	18.3	22.0	22.7
1876-80	30.3	35.3	34.8	18.3	20.8	20.6
1881-85	29.4	33.5	33.3	17.5	19.4	19.6
1886-90	28.8	31.4	31.4	16.4	18.9	18.8
1891-95	27.4	30.5	30.5	16.6	18.7	19.0
1896-00	26.9	29.3	30.0	16.1	17.7	17.9
1901-05	26.1	28.2	29.2	15.5	16.0	17.1
1906-10	25.4	26.3	27.6	14.3	14.7	16.1
1911-15	23.1	23.6	25.4	14.0	14.3[b]	15.7
1916-20	21.2	20.1	22.8	14.5	14.4[b]	15.0
1921-25	19.1	19.9	23.0	12.1	12.1	13.9
1926-30	15.9	16.7	20.0	12.1	12.1	13.6
1931-35	14.1	15.0	18.2	11.6	12.0	13.2
1936-40		14.7	17.6		12.5[b]	13.5
1941			17.5		13.5[b]	14.7
1942			17.6			13.3
1943			18.4			14.0

a. 1855-60.
b. For the years 1915-20 and from 3rd September, 1939, the mortality rates for males and from 1st June, 1941, for females, are based upon civilians only.
c. Death-rates for 1940 onwards are based on civilian population and civilian deaths.

Sources: Statistisk Årsbok för Sverige, 1937, pp. 42, 43.
Registrar-General's Statistical Review of England and Wales, 1940. Part II, p. 6 (birth-rates).
Ditto, 1941. Part I, pp. 3, 4 (death-rates).
Eighty-Ninth Annual Report of the Registrar-General for Scotland, 1943. P. cxxiv.

Official Swedish figures for birth-rates and death-rates are at our disposal from the middle of the eighteenth century, that is, from a time about a hundred years earlier than corresponding statistics in this country. Such records, covering a period of nearly two centuries, are extremely valuable, even though the completeness of registration during the earlier years may perhaps be questioned. Although the birth-rate fluctuated widely from year to year, the diagram shows that the value for quinquennial periods remained almost entirely between 30 and 35 from 1756-60 to 1861-65. In 1866-70 the rate fell below 30 for the first time, and, although it rose again slightly in the succeeding five-year period, it decreased progressively thereafter. The first continuous decline may thus be said to have commenced about 1875.

Official registration began in England and Wales in 1837, but did not become compulsory till 1875. In Scotland it was not started till 1855, but was compulsory from the beginning. In both countries a slight rise in the birth-rate is observable during the early years of registration. There is no reason to believe that any real rise in the birth-rate occurred during this period, and there seems to be little doubt that the explanation lies in the defective registration which one might expect to experience

during the few years following on its introduction. A similar conclusion was reached by Newsholme and Stevenson (1906).

After the initial rise, the birth-rates in Scotland and England remained in the neighbourhood of 35 per 1000 for about twenty years. The first definite fall occurred in 1881-85, and from that time the rates in both countries declined steadily, except that there was a sharp fall during the First World War, followed by a sudden rise immediately afterwards. This temporary deviation from the general trend is not apparent from our table, which only gives average values over quinquennial periods, but in certain single years it was conspicuous. In the Second World War the Scottish birth-rate tended to increase rather than diminish.

Of the three countries, it will be observed, the Swedish birth-rate remains lowest except in 1916-20, whilst for over forty years the Scottish figures have been highest. During the last two decades, in fact, the Scottish rates have been substantially higher than those of England and Sweden.

It is generally accepted that the birth-rate in North-Western Europe did not start to decrease till about 1875. Since that date, with the exception of a sharp fall in certain countries during the First World

War, followed temporarily by a sharp rise, the downward trend has been extremely steady. This decline has been experienced in nearly all civilised countries, including those of South-Eastern Europe, North America, Australia, and New Zealand. In some parts of the world the change has set in considerably later than in others, and it is interesting to note that, generally speaking, the later the period of onset, the more rapid has been the fall.

The trends of the death-rates in the three countries may also be followed from the diagram. That of Sweden is seen to vary, broadly speaking, between 25 and 30 from the middle of the eighteenth century till about 1815. From then on, there was a gradual, but irregular, trend downwards, till the quinquennial rate fell below 20 for the first time in 1861-65. Since about that period it has decreased with greater regularity. The fall in mortality in Sweden, then, appears to have preceded the fall in fertility by many years. During the much shorter period for which reliable English and Scottish death statistics are available, the Scottish curve keeps at a higher level than that of Sweden, and follows a more or less parallel course, whilst the English curve, although also higher than the Swedish for several decades, has stood at practically the same level for many years.

The official record in England and Wales goes back only to 1837, and in Scotland no further than 1855. In both countries the first official Census was not taken until 1801, and subsequent enumerations of the population were made at every tenth year. At the same time, prior to the introduction of official registration of births and deaths in England, returns were obtained of the numbers of burials, baptisms, and marriages throughout the country. These returns, which were derived from Parish Registers, were known to be incomplete, at least in respect of burials and baptisms; as Rickman, who was responsible for the first four Census returns, says in the "Abstract" for 1831 (p. xxxi), "in some places Dissenters from the Established Church and persons inattentive to religious rites are so numerous that the Marriage Register only is worthy of reliance". The defects seem to have been particularly grave in the Scottish returns, but in connection with the English figures various estimates have been made of the error involved, with a view to arriving at approximate values of the true birth-rates and death-rates, at least back to 1801. Rickman himself considered (loc. cit., p. xxxv) that the death-rate exceeded the burial rate by one sixth, and, if we accept this figure, we may make estimates of the death-rates for the earlier years of the

nineteenth century. In Table II we reproduce the proportions of baptisms, burials, and marriages to the population, as given in the 1831 "Abstract" (p.xxxii).

TABLE II.

"Table of the Annual Proportions of Baptisms, Burials, and Marriages, to the Population of England; calculated upon an Average of the Totals of such Baptisms, Burials, and Marriages, in the Five Years preceding the several Enumerations of 1801, 1811, 1821, and 1831."

	Baptisms	Burials	Marriages
1796-1800	1/36	1/48	1/123
1806-1810	1/32	1/49	1/121
1816-1820	1/33	1/55	1/127
1826-1830	1/34	1/51	1/128

Note: This table does not include Wales.
Source: "Abstract" for 1831, p. xxxii.

Table III has been constructed containing the burial rates (annual number of burials per 1000 of the population) corresponding to Rickman's "proportions", and the death-rates calculated by adding one sixth to the burial rates.

TABLE III.

Burial Rates and Death-Rates (annual Burials and Deaths respectively per 1000 Inhabitants), England, 1796-00 to 1826-30.

	Burial Rates	One Sixth of Burial Rates	Death-Rates
1796-00	20.8	3.5	24.3
1806-10	20.4	3.4	23.8
1816-20	18.2	3.0	21.2
1826-30	19.6	3.3	22.9

Note: This table does not include Wales.

The discrepancy between the birth-rate and the baptism rate is probably somewhat greater than that between the death-rate and the burial-rate, and it may be not unreasonable to augment the baptism rate by one fifth in order to obtain an estimate of the birth-rate. The resulting figures are set forth in Table IV, in which the baptism rates are the equivalents of the proportions in Table II.

TABLE IV.

Baptism Rates and Birth-Rates (Annual Baptisms and Births respectively per 1000 Inhabitants), England, 1796-00 to 1826-30.

	Baptism Rates	One Fifth of Baptism Rates	Birth-Rates
1796-00	27.8	5.6	33.4
1806-10	31.3	6.3	37.6
1816-20	30.3	6.1	36.4
1826-30	29.4	5.9	35.3

Note: This table does not include Wales.

If we compare the birth and death-rates in Tables III and IV with those for the period 1841-45, based on the official registration returns, it will be seen that the official figures are lower than the estimates. There is, however, strong reason to believe that at this early date, when the official registration was non-compulsory, it was incomplete, especially with regard to births. The recorded birth-rate, in fact, steadily increased over three decades and ultimately reached a figure in the neighbourhood of 35; it is very probable that the real birth-rate during the whole of this period was constantly in this neighbourhood. The official death-rate from 1845 onwards oscillated between 22 and 23 or thereabouts, a range not very different from that given by the calculated

figures for the period 1796 to 1830. In this way, plausible figures for the birth-rate and death-rate for England may be constructed back to about 1800.

Figures for years prior to 1800 involve even more hazardous assumptions, and become, on the whole, increasingly unreliable the further back we go. The problem is complicated by the absence of reliable enumerations of the total population of the country. The whole subject has been fully discussed by Griffith in his book, "Population Problems of the Age of Malthus", 1926. It contains (p. 43) an interesting graph which shows Griffith's reconstruction of the birth-rates and death-rates in England back to 1700. It appears that the death-rate rose during the first few decades of the eighteenth century and reached a maximum of between 33 and 34 in 1730, after which it fell to about 23 in 1800, with a secondary minimum (27) in 1760 followed by a maximum (29) in 1780. Throughout the century the birth-rate, like that of Sweden, remained almost entirely between 30 and 35. Broadly speaking, we may conclude that, up to recent times, the birth-rate in a country tended to remain relatively constant, whilst the death-rate underwent various fluctuations, according to the economic and social conditions to which the population was subjected. Consequently, variations in the rate of

increase of the population are to be attributed to changes in the death-rate rather than in the birth-rate.

As we have seen, the official registration of births and deaths in Scotland did not begin till 1855, and the Census returns of 1801, 1811, etc., offer little assistance with regard to birth-rates and death-rates, on account of the incompleteness of the relative data. The best we can do, therefore, to obtain some idea of the earlier vital statistics of Scotland, is to make some very general assumptions, justified in a broad sense by the analogous experience of Sweden and England and Wales.

Scotland has one advantage over England in respect of its earlier population history, in that we possess reliable estimates of the number of its inhabitants for times preceding the first Census of 1801. The results contained in Sir John Sinclair's "Statistical Account of Scotland" give information about the population, referred, according to the parish, to the years 1790 to 1798. Sinclair uses this information to make an estimate of the total population of Scotland which may be taken as referring to the year 1795, and amounted to 1,526,492 (Vol. 20, 1798, p. 621). This is reasonably consistent with the figure found at the 1801 Census.

From our present point of view, a much more interesting, because considerably earlier, estimate is that of the Reverend Alexander Webster, D.D. This minister of the Tolbooth Church, Edinburgh, obtained, between 1743 and 1755, from his fellow ministers throughout the country, a fairly accurate count of the inhabitants of every parish. The results of his important investigation are contained in "An Account of the Number of People in Scotland in the year One Thousand Seven Hundred and Fifty-five", a copy of which, in manuscript, is preserved in the National Library, Edinburgh. Although a few typewritten copies are known to be in existence, the work has not been published. Webster computed that the population in 1755 was 1,265,380. Unfortunately the enquiry did not include estimates of the numbers of births, deaths, and marriages.

This 1755 estimate of the population is the earliest one which can be regarded as really accurate. After the Union with England in 1707 an estimate is given in the Parliamentary Reports, and here the figure is 1,048,000. Our authority for this statement is Sinclair (1826, pp. 148-9), but we have not been able to discover the Reports referred to.

About the year 1250, in the reign of Alexander III, the number of inhabitants in Scotland was supposed

to be only about 600,000. According to Sinclair (loc. cit., p. 148), "This number is not given as the result of an actual enumeration, but as the best estimate that could be formed from historic information".

From these estimates of the population of Scotland, along with those found at decennial intervals when the official Census was started in 1801, the yearly rate of increase at different periods may be calculated, on the assumption that we are dealing with a geometric progression. Now, as we have already seen, the birth-rate in England and in Sweden, as far as they can be reconstructed backwards through the early years of the nineteenth and into the eighteenth century, never deviated very much from 35 per 1000. The Scottish figure between 1860 and 1880 was also about 35. We shall therefore assume that the Scottish birth-rate previous to 1860 remained approximately constant at this figure. The difference between the rate of increase shown in the next table and this value of the birth-rate (35 per 1000) is taken to be the death-rate. It has to be kept in mind that the rate of change of the population involves, not only the birth-rate and the death-rate, but also immigration and emigration. Emigration was probably on a small scale up to 1821 (where our table stops), and the net effect of emigration and immigration from

Ireland is not likely to have been an important one. However, the whole method is obviously open to criticism in view of the rather speculative nature of the assumptions made, and the results of Table V should be regarded merely as an indication of the probable trend of the death-rate in Scotland in pre-registration days.

TABLE V.

Death-Rates in Scotland, 1250 to 1821, derived from the Rate of Increase of the Population; assuming that the Birth-Rate remains constant.

	Population	Interval in years	Annual Rate of Increase per 1000 Inhabitants	Death-Rate, assuming Birth-Rate = 35 per 1000
1250	600,000			
		457	1.2	33.8
1707	1,048,000			
		48	3.9	31.1
1755	1,265,380			
		40	4.7	30.3
1795	1,526,492			
		6	8.7	26.3
1801	1,608,420			
		10	11.6	23.4
1811	1,805,864			
		10	14.8	20.2
1821	2,091,521			

This somewhat speculative series of figures for the birth-rates and death-rates of Scotland in the distant past can only be taken as indicating the

average levels over the various epochs. In particular years, or even during considerable periods, there may have been wide fluctuations. The death-rate, in particular, might change rapidly from year to year, when epidemics such as the plague were wont to sweep over the nation, decimating the population. However, in the absence of any reliable vital statistics for Scotland based on direct observation, such a reconstruction may perhaps be justified.

2. THE OBJECT OF THE PRESENT STUDY.

It is with this background in mind, and especially the more recent changes in fertility and mortality, that the present study has been undertaken. Broadly speaking, our object has been to make a comparison between the urban and rural districts of Scotland, particularly from the point of view of the influence of the different types of environment on the health of the community. The period covered is from 1855, when official registration was introduced, to 1943, the last year for which the Registrar-General's Annual Report is available.

In view of the complexities of the geographical classification employed from time to time by the Registrar-General in his Reports, and the large number of technical terms which are needed in vital statistics, it seemed desirable to devote Chapter II to a brief survey of the geographical divisions of the country, and definitions of the various measures of mortality and fertility. The substance of the study is contained in Chapters III, IV, and V.

Chapter III is devoted to an analysis of the death-rates in the town and country districts of Scotland. Our aim here has been to select the indices of mortality best suited for the assessment of the

relative "healthiness" of the urban and rural environments, and to present an analysis of the data in terms of these indices.

In Chapter IV, the mortality due to cancer is specially analysed, both in respect of its geographical distribution and of the changes which have taken place between the decade 1921-30 and the period 1931-37. In order to shed further light on certain problems, an analysis has also been made in respect of the various tumour locations, and the results are discussed from several points of view.

Finally, in Chapter V, the fertility of Scottish women is discussed from two points of view - firstly, the differences in fertility between various geographical areas, and, secondly, the changes in fertility which have taken place during the past seventy years. Here, too, the differences between town and country areas have been kept in view.

In the last chapter the results are summarised, and some general conclusions drawn.

CHAPTER II.

DEFINITIONS.

1. THE URBAN AND RURAL DIVISIONS OF SCOTLAND.

A description will now be given of how Scotland has been divided, for statistical purposes, into various groups of districts, having different urban or rural characteristics. As nearly all the raw data employed in our work have been extracted from the Annual Reports of the Registrar-General and from the Census Reports, it has been necessary to employ throughout the classification adopted in these publications. The following is a brief summary of this classification, and indicates the changes which have been introduced from time to time by the Registrar-General. These changes are represented graphically in Diagram 2, which shows how the relative proportions of the different groups have altered during the past eighty years. The actual populations of the groups, as enumerated at each Census, is given in Table VI. No Census having been taken in 1941, estimates of the populations of the various groups in 1939 have also been included. Limited use of the National Register of 1939 was made by the Registrar-General in drawing

up these estimates. The table also contains the percentage proportion which each population represents of the entire country. Corresponding figures for certain individual Principal Towns and Large Burghs have been collected in Appendix B.

It is noteworthy that in 1939 the population of Scotland exceeded five million for the first time in its history, having doubled in a hundred years.

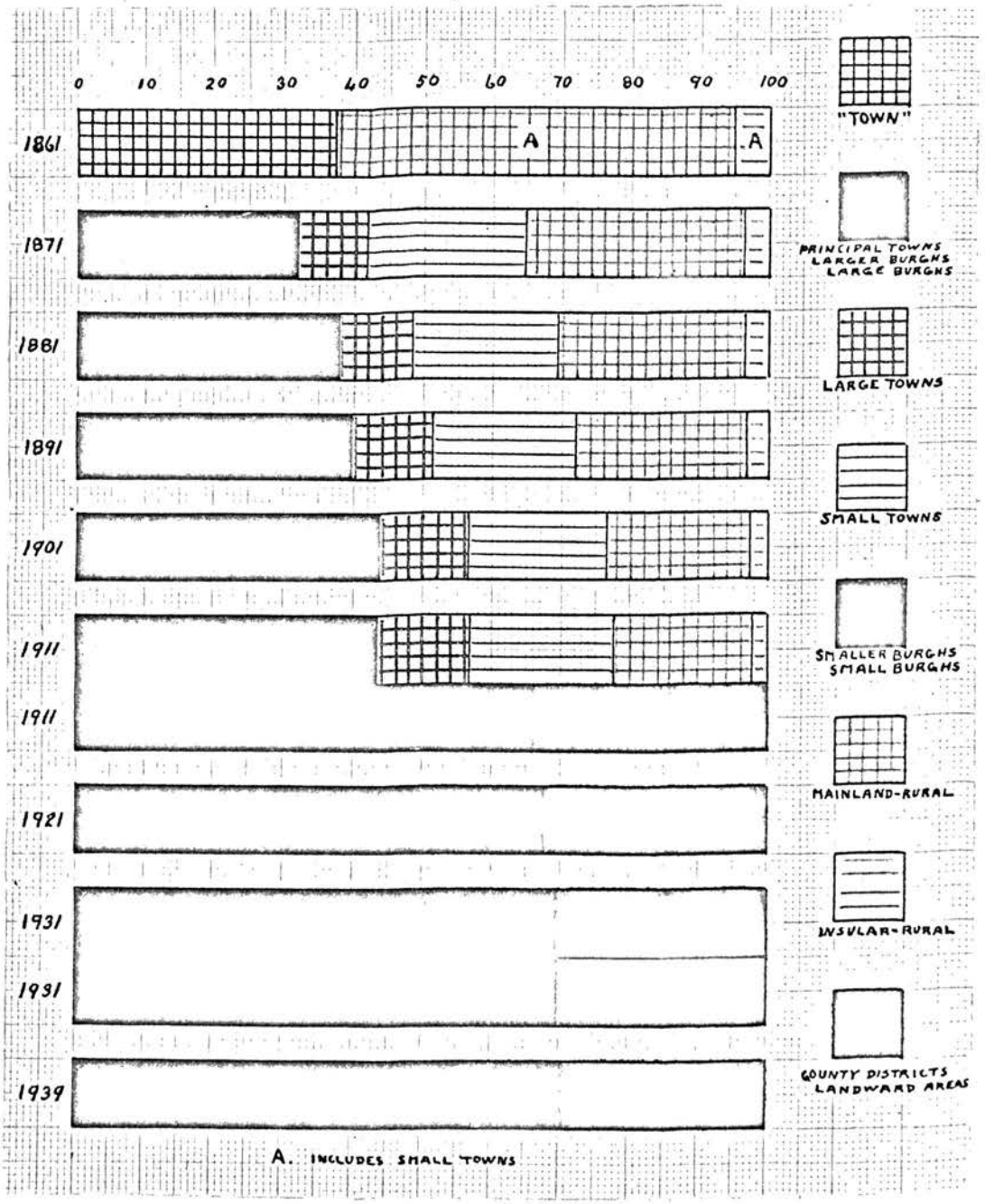


Diagram 2.

The Populations of the Urban and Rural Divisions of Scotland, expressed as Percentages of the Population of the Entire Country, 1861 to 1939.

TABLE VI.

The Population of the Urban and Rural Divisions of Scotland, 1861 to 1939.

Census Year	Town		Mainland-Rural		Insular	SCOTLAND
1861	1,138,184 37.2		1,763,377 57.6		160,733 5.2	3,062,294
	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	
1871	1,068,556 31.8	334,257 9.9	776,087 23.1	1,049,114 31.2	132,004 3.9	3,360,018
1881	1,411,536 37.8	388,797 10.4	790,796 21.2	1,014,056 27.1	130,388 3.5	3,735,573
1891	1,590,310 39.5	467,872 11.6	840,339 20.9	1,001,174 24.9	125,952 3.1	4,025,647
1901	1,950,297 43.6	578,769 12.9	897,326 20.1	929,042 20.8	116,669 2.6	4,472,103
1911	2,062,592 43.3	638,891 13.4	1,000,156 21.0	947,667 19.9	110,139 2.3	4,759,445 (Preliminary Census Report)
	Larger Burghs		Smaller Burghs		Country Districts	
1911	2,166,847 45.5		973,572 20.4		1,620,485 34.0	4,760,904
1921	2,363,896 48.4		947,163 19.4		1,571,438 32.2	4,882,497
1931	2,453,319 50.7		908,065 18.8		1,481,170 30.6	4,842,554 (Provisional census population)
	Large Burghs		Small Burghs		Landward Areas	
1931 (E)	2,631,320 54.3		730,309 15.1		1,481,351 30.6	4,842,980
1931 (R)	2,647,043 54.7		725,044 15.0		1,470,893 30.4	4,842,980
Estimated 1939 (S)	2,760,600 55.1		764,200 15.3		1,481,900 29.6	5,006,700

Note: We subdivided the Town population of 1861 into Principal Town and Large Town by subtracting the sum of the eight individual Principal Towns, 884,154 (28.9%), from the Town population. The result, 254,030 (8.3%) was the Large Town population.

(E) Population actually enumerated in each group.
(R) Population referred to group in which normally resident.
(S) The 1939 figures are estimates, not enumerations.

The figure beneath the population of each division is the percentage ratio of the population to that of the entire country.

The geographical units from which all Scottish vital statistics are collected are the registration districts, each of which, generally speaking, corresponds to a parish. The populations of these districts, about 900 in number, range from a few hundreds to over 90,000.

In the Annual Reports from 1855 to 1870, Scotland was divided into three groups of districts. These divisions were known as "Town", "Mainland-Rural", and "Insular". The Town Group embraced all the towns, about twenty in number, with populations above 10,000. The Insular Group included Orkney, Shetland, Bute, and the islands of Ross and Cromarty, Inverness, and Argyll. The Mainland-Rural Group was composed of the entire mainland excluding the Town portion, and consequently contained the numerous small towns with populations less than 10,000.

In 1871 a further subdivision of the above three groups into five was carried out, and this arrangement continued till 1911. The new groups were defined as follows.

1. The group of "Principal Towns", consisting till 1901 of those towns which had populations exceeding 25,000. A change was made in 1901, raising the lower limit of a Principal Town to 30,000. Under this category in 1871 were Glasgow, Edinburgh, Dundee, Aberdeen, Paisley, Greenock, Leith, and Perth. By

1910, due to their increasing population, Partick, Govan, Kilmarnock, Coatbridge, Hamilton, Motherwell, and Kirkcaldy had been added to the list.

2. The Group of "Large Towns", containing all towns with populations between 10,000 and the lower limit for Principal Towns.

3. The Group of "Small Towns", each having a population of from 2,000 to 10,000.

4. The "Mainland-Rural" Group, comprising the whole of the mainland not included in the foregoing urban groups. It differed substantially from the group of the same name prior to 1871, in that it did not contain any small towns.

5. The "Insular-Rural" Group, being the Insular Group mentioned above, leaving out the Small Towns of Kirkwall, Lerwick, Stornoway, and Rothesay.

In 1911 the system of preparing and publishing the vital statistics of Scotland was completely reorganised. Amongst other innovations, a fundamental change was made in the presentation of statistics for the urban and rural divisions of the country. Although the ultimate unit continued to be the Registration district, the new scheme was based on Public Health Districts. These were defined in the Public Health (Scotland) Act, 1897, and consisted of burghs, each taken separately, and county, or extra-burghal,

districts. Burghs are often quite small, for example East Linton and Dornoch with populations of less than 1000, whilst, on the other hand, certain medium-sized towns, such as Cambuslang with a population over 25,000, do not possess burghal status. Three great groups of Public Health Districts were created, namely:

1. The Group of "Larger Burghs", those with populations exceeding 30,000. This group included, in addition to the towns already given under Principal Towns, Falkirk, Clydebank, and Ayr, which had attained populations of 30,000 in the 1911 Census, but in 1911 were not ranked as Principal Towns, not having been in that category according to the 1901 Census. This evidently accounts for the fact that in 1911 the Larger Burghs formed 45.5 per cent. of the entire country, whereas the Principal Towns formed only 43.3 per cent. A possible minor cause of discrepancies between the populations of Towns and Burghs lies in the fact that the boundaries of the "Town" and corresponding "Burgh" are not always coincident. In 1913 the boundaries of Glasgow were extended to take in Partick and Govan, while in 1921 those of Edinburgh were altered so as to include Leith. In the same year Dunfermline became a Larger Burgh, bringing the number up to sixteen.

2. The Group of "Smaller Burghs", consisting of those with populations of less than 30,000.

3. The Group of "County Districts", being the rest of the country.

The classification just outlined has remained in force to the present day with only one major alteration, namely, that in 1931 the lower limit for Larger Burghs was reduced from 30,000 to 20,000, (the population being that given by the Census of 1921), and Arbroath, with a population of over 19,000 in 1921, was specially included. This increased the number of Larger Burghs from sixteen to twenty-four. At the same time the nomenclature was changed from Larger Burghs, Smaller Burghs, and County Districts, to "Large Burghs", "Small Burghs", and "Landward Areas".

The change brought about in 1911, however necessary it may have been for administrative purposes, was regrettable from the statistician's point of view, resulting, as it did, in a serious break in the continuity of urban and rural statistics. Although the Larger Burghs are more or less identical with the Principal Towns which they replace in the Annual Reports, a comparison of the two methods of classification, both referring to 1911 (see diagram), will show that there is considerable difficulty in deciding

which of the other groups of the older classification are most suitable for comparison with those of the new. For example, in 1911 Large Towns made up 13.4 per cent. of the population of Scotland and Small Towns 21.0 per cent., whilst the new Group of Smaller Burghs comprised 20.4 per cent. All things considered, it is thought permissible to regard the Large Towns as being continued in the Smaller Burghs, though the latter category also includes many Small Towns.

There is, unfortunately, no group in the new system which compares, except approximately, with the old Mainland-Rural. It will be observed that this division constituted 19.9 per cent. of the country in 1911, whereas the new County Districts, owing to the inclusion of numerous towns not having burghal status (although often of considerable size), accounted for 34.0 per cent. This group (known since 1931 as Landward Areas), although representative of the country, has the serious drawback of not being uniformly rural in character, especially in certain areas, such as the central industrial belt. Here, in the counties comprising what are called the East- and West-Central Divisions, it was found at the 1931 Census that 58.6 per cent. of the Landward portion was enumerated in urban districts, whilst, in the Landward Areas to the north and south of this belt, the percentage was only 3.7. In spite of the obvious objections,

however, the County Districts and the Landward Areas, spread over the country as a whole, may be taken in many statistical investigations as representative of rural Scotland.

No serious break in continuity resulted from the alterations made in 1931, as the only effect was to raise the population of the Larger Burghs from 50.7 to 54.3 per cent. of that of Scotland (the Smaller Burghs falling correspondingly from 18.8 to 15.1 per cent.).

2. MEASURES OF MORTALITY.

Although it would be more logical to discuss fertility before mortality, it has been decided to deal with the latter first. Our principal reason for so doing is that various measures of fertility employed are more easily described, and their significance more clearly realised, after a knowledge has been gained of certain mortality measures to which they are closely related.

(a) The Crude Death-Rate.

In order to compare with one another the mortality experience of a number of communities, or to observe the difference in mortality of a particular community at intervals of time, it is necessary to relate, in one way or another, the number of deaths in each community to the number of its inhabitants. The obvious and most elementary method is to compute the ratio between the deaths in one year and the average total living population throughout that year. This measure of mortality is known as the "crude death-rate", or simply the "death-rate" (cf. Table I). For many years it has been customary to express this index as the annual number of deaths per 1000 average total population, the latter being, as a rule, the estimated mid-year population.

The crude death-rate is an accurate reflection of the healthiness of the community only when the age and sex distribution is kept constant. Two communities with different age and sex distributions may in reality be equally healthy, but show quite different crude death-rates. In order, therefore, to be able to draw conclusions about the community's health from mortality statistics, it is necessary to "correct" or "standardise" the crude death-rate.

(b) Age Specific Death-Rates.

A more complete and accurate picture of mortality is got by computing the annual number of deaths of males and females, at different ages, per 1000 males and females respectively of the same age. For most countries which collect vital statistics these "age specific death-rates" are easily obtainable, for the age at death is almost invariably recorded on the death certificate. A full account of mortality can only be obtained by calculating such rates for individual diseases and causes of death. When, owing to the incompleteness of data, the sexes cannot be separated, age specific death-rates for persons may be computed. Age and sex specific death-rates for all causes combined are shown in Table VII, for Scotland, from 1860-62 to 1930-32. The deaths on which this table

is based are averages over triennial periods centred at Census years.

TABLE VII.

Age Specific Death-Rates for all causes combined, Scotland, for the triennial periods centred at each Census year from 1861 to 1931.

Age	Sex	1860-62	1870-72	1880-82	1890-92	1900-02	1910-12	1920-22	1930-32
All Ages	Male	22.4	23.1	20.4	20.1	18.5	15.6	14.8	13.9
	Female	20.6	21.3	19.0	19.2	17.3	14.8	13.6	12.8
-1	M.	152.0	159.5	150.0	159.0	158.4	137.4	118.7	101.6
	F.	126.4	130.8	121.3	129.6	126.0	109.0	90.4	78.0
1-	M.	37.4	35.3	29.5	27.5	22.8	18.4	15.7	10.4
	F.	37.4	35.3	28.8	27.1	21.5	17.4	14.6	9.6
5-	M.	9.1	9.8	7.8	5.7	4.3	3.7	3.0	2.7
	F.	8.8	9.3	7.3	6.0	4.4	3.8	2.9	2.3
10-	M.	5.2	5.4	4.3	3.5	2.8	2.4	2.0	1.7
	F.	5.1	5.8	4.7	4.0	3.2	2.5	2.0	1.6
15-	M.	8.7	9.2	7.1	6.5	5.4	4.0	3.5	3.0
	F.	7.6	8.5	7.0	6.2	5.1	3.9	3.4	2.8
25-	M.	10.3	11.2	8.9	8.3	8.5	5.6	4.9	3.9
	F.	9.6	10.4	9.2	8.8	7.3	5.5	5.0	3.9
35-	M.	12.3	14.0	12.4	12.2	11.7	8.5	7.2	6.6
	F.	11.5	12.4	11.0	11.6	10.0	8.0	6.7	5.5
45-	M.	17.2	20.0	19.4	20.8	19.5	15.6	12.7	11.6
	F.	14.4	16.1	14.8	15.8	15.6	12.5	10.4	9.4
55-	M.	29.5	32.5	33.4	37.2	37.9	31.3	27.8	24.6
	F.	24.9	27.2	26.6	31.6	30.5	25.2	21.9	19.7
65-	M.	64.6	64.1	63.6	72.1	71.6	65.3	61.4	60.5
	F.	56.6	54.6	53.3	61.8	60.2	52.8	48.5	47.1
75+	M.	166.5	159.7	148.1	165.2	159.2	148.7	154.1	154.6
	F.	155.1	150.3	136.6	149.8	142.8	134.7	135.3	137.3

Female death-rates underlined in red are those which exceed the corresponding male death-rates.

Source: Seventy-Eighth Annual Report of the Registrar-General for Scotland, 1932, p. xl.

The two notable features of age and sex specific death-rates are at once apparent. Firstly, the rates of mortality begin with high values in infancy, drop to a minimum in the age-group 10-15, and then steadily increase to the end of life. Secondly, the male death-rate at each age is generally higher than the female. Instances where the reverse holds good have been underlined in red. These occur only eleven times out of eighty-eight, and are restricted to ages below 35.

The one great drawback to the general use of specific death-rates is that, when reviewing by their means the mortality of different countries or regions at different periods of time, the array of figures presented is so vast that it is difficult to form a comprehensive view of the situation as a whole. Thus, for less exacting comparisons, and for the simple classification of mortality records, it is desirable, when detailed age analysis is not essential, to be able to express a series of age mortalities by a single number. Four concise indices of mortality will now be described, each of which condenses an array of age specific death-rates over a wide span of life into one simple number. These are the "standardised death-rate", the "equivalent average death-rate", the "stationary population death-rate"

(Kuczynski's index), and the "generation mortality coefficient".

(c.1) The Standardised Death-Rate.

We can regard the crude death-rate as that which is obtained by acting on the age-groups of the actual population by the corresponding specific death-rates. The drawback to this index is that the actual age distribution of the population is uncontrolled; the accidents of history determine its composition and consequently it varies from country to country, and at different times in the same country. It is a natural step, therefore, to apply the age specific death-rates, not to an "accidental" age distribution of this type, but to some standard population. In this way we obtain the "standardised death-rate" (cf. Table VIII). Its value will clearly depend on the standard population chosen. The English Registrar-General has for many years used as his standard population the population of England and Wales at the 1901 Census. In addition he has sometimes employed the International Standard Population, 1900, which was proposed by the International Institute of Statistics in 1917 (Annuaire, 1917). It is made up of the aggregate populations of a number of European countries about 1900.

The drawback to the use of such a standardised death-rate lies in the arbitrariness of the standard

population. Standardised death-rates vary according to the standard population used, and even the relative difference between two countries at the same time, or the same country at different times, may alter considerably with the use of different standard populations.

The method of standardisation just described can only be carried out if we know the specific death-rates of the community under review. It not infrequently happens, however, as when comparing the mortality experience of different small areas, such as the counties of Scotland, that specific death-rates for the separate areas are not available, thus making it impossible to use the method which has been explained above. In such circumstances it is customary to adopt an alternative method of standardisation, closely related to that already described. This so-called "indirect" method will now be briefly outlined.

A standard set of specific death-rates is chosen, for example those of Scotland as a whole, and, by applying these to the respective age-groups in the population of each local area, a "calculated death-rate" is obtained. This, when divided into the death-rate of Scotland as a whole, yields a factor for each local area. The crude death-rate of the area

is multiplied by this factor to obtain the "standardised" death-rate for that area.

An example of the actual process of calculating such factors will be found in Chapter IV, in which extensive use has been made of this indirect method of standardisation.

It may easily be proved, provided the ratios of the corresponding specific death-rates in the different populations are constant, that the death-rates standardised by the direct and the indirect methods, are in exact agreement.

Both systems, with modifications employed in their practical use, are fully described in the English Registrar-General's Decennial Supplement, 1921 (Part III, p. xxxiii), in which he also gives an interesting history of standardisation in England.

(c.2) The Equivalent Average Death-Rate.

To remove the arbitrariness of the standard population (referred to above), a natural suggestion is to employ a population with equal numbers in all age-groups. Clearly we cannot allow this population to include high age-groups entirely outwith the limits of human experience. Indeed, it is obviously desirable to exclude age-groups over, say 70, as otherwise the very high specific death-rates at such high ages would unduly weight the resulting death-rate. In

practice this method has been used more for the calculation of death-rates from specific diseases than for total death-rates, and, when dealing with specific diseases, the range over which the hypothetical population may appropriately be extended, is often fairly obvious. For example, when dealing with deaths from cancer it is customary to exclude ages under 25, as cancer is very rare below this age, and to take as upper limit the age 65. This method, of course, is equivalent to taking the simple average of age specific death-rates over the range in question. It has been discussed by Pearl (1930) and Yule (1934), and has been used by the English Registrar-General in his more recent Reports. Examples of this "equivalent average death-rate", for cancer of various organs, will be found later in Table XXIX (Chapter IV).

(c.3) The Stationary Population Death-Rate.

Even the equivalent average death-rate contains a considerable element of arbitrariness, in that the range of age-groups has to be limited at discretion. Now, it happens that, given a complete series of specific death-rates, it is possible to generate from it a population distribution with which the series has a unique relation. If we imagine a population in which the specific death-rates operate, and whose birth-rate is such that the number of births is equal

to the number of deaths, the total number in the population will remain constant, and a stationary age distribution will ultimately establish itself, after initial fluctuations. It is not difficult to see that this stationary age distribution is in fact proportional to the age distribution of survivors in the life table constructed with the use of the specific death-rates in question. This age distribution is clearly a natural one to use for standardising the death-rate. The death-rate so standardised will also be the death-rate of the stationary population, and is conveniently called the "stationary population death-rate".

It is not difficult to show that the stationary population death-rate is the reciprocal of the expectation of life at age zero, calculated with the help of the same specific death-rates, that is, based on the same life table. The use of the stationary population death-rate is strongly recommended by Kuczynski, who, in order to facilitate its calculation, has described a simple method of constructing an abridged life table (1935, p. 170). It is, of course, essentially equivalent to the expectation of life at age zero, which has been used for many years as a measure of the vitality of populations.

The great advantage of the stationary population

death-rate is its freedom from any arbitrary or adventitious factor. Its disadvantage lies in the fact that the population on which the specific death-rates are assumed to operate is itself a complicated function of these specific death-rates. If we are comparing two different populations, this index involves allowing their specific death-rates to operate on two distinct age-group distributions. Usually the difference between the two age-group distributions is such as to oppose the direct effect of the difference in specific rates; thus, if specific rates are lowered, the general result is to increase the number of the aged in the stationary population, and so to reduce the fall in the stationary population death-rate to considerably less than it would be if the age-group distribution had remained constant.

Examples of crude, standardised, and stationary population death-rates are given below.

TABLE VIII.

Crude, Standardised, and Stationary Population Death-Rates, England and Wales, 1871-80 to 1933.

	Crude Death-Rate	Standardised Death-Rate	Stationary Population Death-Rate
1871-80	21.4	20.3	23.28
1881-90	19.1	18.6	22.03
1891-00	18.2	18.1	21.78
1901-10	15.4	15.2	19.83
1910-12	13.8	13.4	18.73
1920-22	12.4	11.6	17.38
1933	12.3	9.8	16.45

Source: Kuczynski, 1935, p. 193.

Note: The figures for the crude death-rate are taken from the Registrar-General's Statistical Review (1941, Part I, p. 3), and differ from those given by Kuczynski for the first two decades. The standard population used is that of England, 1901.

It is noteworthy that throughout the period covered by the above table, the crude death-rate lies between the standardised death-rate and the stationary population death-rate. This reflects the fact that the standard population chosen happens to contain an unusually large proportion of young adults, the stationary population contains at all periods, but especially in the more recent years, a high proportion of old people, and the actual population, both before

and after 1901, is intermediate in character.

(c.4) The Generation Mortality Coefficient.

In two papers published in 1934 Kermack, McKendrick, and McKinlay showed that for Scotland the specific death-rate $f_{t,\theta}$, for age θ in the calendar year t, may, to a close approximation, be expressed in the form $\beta_\theta \alpha_{t-\theta}$, where β_θ is a function of the age alone, and $\alpha_{t-\theta}$ depends only on $t-\theta$, the date of birth. Clearly both α and β are arbitrary to the extent of a multiplying constant, but this arbitrariness can be removed if we choose the set of β_θ factors so that their product is equal to unity. The factor $\alpha_{t-\theta}$ is then fixed for each $t-\theta$, and is characteristic of the group of individuals born in this year. It may be taken as a measure of the general mortality of this generation of individuals, and will be referred to as the "generation mortality coefficient". This coefficient will be employed extensively in Chapter III in our comparison of mortalities in the town and country districts of Scotland during the past seventy years, and will be discussed in much greater detail in that chapter.

(d) The Infantile Death-Rate.

The death-rate of children under one year of age, a special case of the age specific death-rate, is, on

account of its relative severity, of very great importance. When not forming part of a complete table of specific death-rates it is frequently computed by relating the annual number of deaths of children under one year, not to the average number of children of that age - which may be somewhat difficult to estimate - but to the annual number of births in the same year, and in this form is referred to as the "infantile death-rate". - It is obvious, if the birth-rate is rapidly changing (as for example in the years 1919-21), that this measure of mortality may give somewhat misleading results. But for most practical purposes it is sufficiently accurate.

3. MEASURES OF FERTILITY.

(a) The Crude Birth-Rate.

This index, which is defined as the annual number of births per 1000 total mean population, is an accurate measure of fertility only when the proportion of women of child-bearing age in the population is constant and when their age distribution remains unaltered. Two different communities in which the women at corresponding ages are equally fertile may show quite different crude birth-rates (cf. Table I). Because of the limitations of the crude birth-rate as a measure of fertility, various other indices have been devised, of which the following are the most important.

(b) General Fertility Rates.

A first step towards the accurate measurement of fertility is to relate the number of births to the total number of women of child-bearing age. Relatively few children are born to women under 15 or over 45, and therefore for a long time it has been customary in Britain to relate the births to the number of women within this age range. The resulting index, the annual number of births per 1000 women aged 15-45, is called the "general total fertility rate".

For many purposes it is important to divide births into legitimate and illegitimate. These are naturally related to married and single women respectively, the latter being unmarried, widowed, or divorced. Thus, besides the general total fertility rate, we have the "general legitimate fertility rate", the annual number of legitimate births per 1000 married women aged 15-45; and the "general illegitimate fertility rate", the annual number of illegitimate births per 1000 single women aged 15-45. Many examples of these indices are given in the chapter on fertility.

(c) Specific Fertility Rates.

The fertility of women depends very largely on their age, and it follows that the general fertility rate is an adequate guage of fertility only when the age distribution of women remains constant within the age range 15-45, the approximate age limits of childbearing. For this reason it is important to consider fertility for different ages of the mother. In practice it is not usually convenient to calculate the specific rates for every single year of age, but it is usually sufficient to work with five-year age-groups, for example, 15-19, 20-24, etc. Such "specific fertility rates" are of three kinds. We have:

"specific total fertility rates", the total number of children born to mothers of a particular age per 1000 women of that particular age; "specific legitimate fertility rates", the number of children legitimately born to married women of a particular age per 1000 married women of that age; and "specific illegitimate fertility rates", the number of children illegitimately born to single women of a particular age per 1000 single women of that age. From the biological point of view, importance attaches to the specific total rates; but when the interpretation of the figures in terms of known social factors is the objective, the legitimate fertility rates are especially useful, because they refer to more homogeneous groups.

The information necessary for calculating such rates, namely the mother's age when a child is born, has been available in some countries for many years. In Scotland the requisite information is obtainable for the first year of official registration, 1855, but the rates computed therefrom (Lewis and Lewis, 1906) are undoubtedly somewhat low on account of incomplete registration. From that time until the publication of the Eighty-Third Annual Report of the Registrar-General, 1937 (published in 1938), no official specific fertility rates for Scotland were available. In this report, estimates derived from a special count

made on the 1931 Census returns are given, and will be referred to again in Chapter V. As a result of the Population (Statistics) Act, 1938, specific fertility rates became available from July 1938 onwards. These rates for the second half of 1938 were published in the Eighty-Fourth Report, and those for the following five years in the Eighty-Ninth Report (for 1943).

When comparing the fertility of different communities by means of their specific fertility rates, it is often difficult, on account of the confusing arrays of figures presented, to get a clear and simple picture of the situation. It is thus desirable, when detailed analysis by age is not required, to be able, as when dealing with specific death-rates, to represent a series of specific fertility rates by a single index. Six indices of this type will now be defined, each of which takes into account the age and sex constitution of the population. These are: the "standardised birth-rate", "standardised general fertility rates", the "gross fertility rate" (called by Kuczynski the total fertility), the "gross reproduction rate", the "net fertility rate", and the "net reproduction rate".

(d.1) <u>The Standardised Birth-Rate</u>.

The crude birth-rate may be regarded as derived by the action of the specific total fertility rates on the corresponding female age-groups of the actual

population. Consequently, on account of the "accidental" age and sex distribution of the population, it is unsuitable for making comparisons. By applying the specific total fertility rates of different communities to a chosen standard population we obtain, for each, its "standardised birth-rate". When specific fertility rates for each community are not available, an "indirect" method of standardisation may be used. The process employed is similar to that adopted for the indirect standardisation of the death-rate, to which reference has already been made. Standardised birth-rates are very rarely used in practice.

(d.2) Standardised General Fertility Rates.

In the general fertility rate the proportion of women within the age-group 15-45 in the community has been allowed for, but not the age distribution within this age range. For this reason it may be desirable to standardise the general fertility rate in respect of the age distribution, and this may be done either by the direct method or by the indirect method. Considerable use has been made of the indirect method of standardising the general legitimate fertility rate in Chapter V, and the details of the process will be more fully discussed there.

(d.3) The Gross Fertility Rate.

Instead of an arbitrary standard population we may choose one in which the numbers of women in all age-groups are the same. This method gives an index which corresponds to the equivalent average death-rate. It is convenient, however, instead of taking the average of the specific rates to take the sum. The resulting index is best called the "gross fertility rate". (Kuczynski (1935, p. 117) calls it "total fertility", but see section (e) below.) It represents the total number of children born to 1000 women passing through the child-bearing age, it being assumed that all these women survive. As it is often inconvenient to calculate specific rates for each year of age, in practice it is customary to take five times the sum of the specific rates for quinquennial age-groups. As might be expected, the two methods give approximately the same results.

(d.4) The Gross Reproduction Rate.

In calculating fertility rates we use the number of births of both sexes; for certain purposes it is desirable to work only with female births, and we speak of "reproduction rates". Thus, the "gross reproduction rate" is obtained by summing the specific reproduction rates for various ages, and gives the number of female children born to 1000 women passing

through the child-bearing age, assuming that none of the women dies. In practice the specific reproduction rates are not readily obtained, because it is not usual to classify children according to both age of the mother and sex. As, however, the sex ratio at birth does not significantly depend on the mother's age, the gross reproduction rate may be calculated by multiplying the gross fertility rate by the proportion of all female births to total births in the community.

(d.5) The Net Fertility Rate.

Corresponding to the stationary population death-rate we have the "net fertility rate". To calculate this we operate with the specific fertility rates on the corresponding female age groups of the stationary population.

(d.6) The Net Reproduction Rate.

The "net reproduction rate" is, of course, similarly obtained by operating with the specific reproduction rates on the corresponding female age-groups of the stationary population, and the resulting index yields the number of female children born, on the average, to 1000 newly born girls during their lifetime, it being assumed that they die off in accordance with the life table based on the existing specific death-rates. If the net reproduction rate is above unity, the population, after possible

fluctuations, will ultimately increase exponentially; if it is below unity, the population will ultimately die out exponentially; whilst, if it is equal to unity, the population will approach, and ultimately settle down to, a steady state, with fixed age distribution and constant total size.

(e) A Suggested Nomenclature for Measures of Fertility.

In view of the many measures of fertility which are encountered in vital statistics, it is important that the nomenclature should be as simple and systematic as possible. The following scheme is suggested as convenient and logical. It seems to embrace most of the commonly used indices, and to involve minimum changes in the nomenclature at present accepted. The only deviation from the existing nomenclature is the replacement of "total fertility" (Kuczynski, 1935, p. 117) by "gross fertility rate".

The scheme is based on the following three sets of terms.

(A) Legitimate, Illegitimate, Total.

(B) General, Specific, Gross, Net.

(C) Fertility, Reproduction.

The following definitions are suggested.

(A) Legitimate, referring to legitimate children and married women.

Illegitimate, referring to illegitimate children and single women.

Total, referring to all children and all women.

(B) General, for the age-group 15-45, or 15-50, etc.

Specific, for a particular age, or age-group.

Gross, being the sum of the specific rates for every year of age.

Net, being the sum of the specific rates for every year of age, weighted according to appropriate lx values.

(C) Fertility, to refer to all children, male plus female.

Reproduction, to refer to female children only.

When the word "rate" is added at the end, the index is per 1000 women; when the word "rate" is omitted, it gives the average per woman.

In general, any index is denoted by three terms, one from (A), one from (B), and one from (C), the word rate being added when the index has been calculated on a basis of 1000 women. Thus, the "general total fertility rate" is the total children born per year per 1000 women aged 15-45; the "specific legitimate fertility rate" is the number of legitimate children born to mothers of a particular age, per 1000 married women of that particular age. It is, of course, possible that certain indices accommodated by the above scheme have little practical significance, and will be rarely, if ever, used.

(f) Fertility by Age of Mother and Duration of Marriage.

The fertility of married women depends not only on age but also on duration of marriage. Fertility rates taking into account both these factors would therefore be extremely useful in the study of fertility problems, such as the falling birth-rate. Rates of this type are not at present obtainable for Scotland, but, as the result of the Population (Statistics) Act of 1938 and the recent official sample population survey, they may become available in the near future. As far as we are aware, Sweden is the only country for which rates of this kind have already been calculated. These were worked out at the Statistical Institute of the University of Lund by Professor Wicksell and his colleagues, who kindly sent us a copy of their results. These are of such unusual interest that we have prepared an abridged version, which is reproduced in Table IX (cf. Wicksell and Quensel, 1938). Our method of presentation has been to arrange the rates at intervals of five years - for age of mother, duration of marriage, and calendar year.

TABLE IX.

Fertility Rates for Age of Mother and Duration of Marriage, Sweden, at five-year Intervals from 1914 to 1934.

Age-groups	Duration of Marriage	1914	1919	1924	1929	1934
15-20	2-3	331.2	355.6	278.7	275.3	243.9
20-25	2-3	316.7	292.7	257.5	219.1	190.7
	7-8	232.3	214.3	162.8	160.3	125.0
25-30	2-3	300.9	266.6	243.4	206.5	177.3
	7-8	222.8	195.2	168.5	133.7	111.7
	12-13	263.7	155.6	133.9	179.4	74.1
30-35	2-3	285.9	258.1	228.5	189.9	170.3
	7-8	202.2	180.4	146.4	117.3	100.8
	12-13	190.5	154.8	132.7	102.6	81.2
	17-18	209.6	187.0	189.0	113.8	27.0
35-40	2-3	241.7	215.8	193.1	159.5	136.0
	7-8	172.9	160.0	127.1	99.4	77.4
	12-13	159.5	125.3	108.8	77.0	60.4
	17-18	153.0	123.5	107.1	81.8	59.1
40-45	2-3	140.4	119.9	98.6	79.7	69.9
	7-8	102.3	84.7	76.5	55.1	42.7
	12-13	90.7	71.8	65.7	43.9	34.3
	17-18	91.8	71.3	56.6	43.3	27.7

Most of the figures given above are derived from the original table by taking the unweighted averages for three consecutive durations of marriage. The rates for 1914 and 1929 are the averages for triennial calendar periods. The age-group 45-50 has been omitted.

For age of mother up to 35 fertility falls more rapidly with increase of duration of marriage than with increase of mother's age; at higher ages the

fall appears to be greater for an increase in the mother's age.

Clearly, under present conditions, it may be just as important in any adequate survey of fertility to take into account the duration of marriage as well as the age of the mother. Other factors, such as the number of children already born, may also have a significant influence on fertility. However, in the absence of any data suitable for the investigation of these factors, it is necessary to concentrate on the rates as affected by the age of the mother only, and the discussion in Chapter V is perforce limited to this aspect of the problem.

CHAPTER III.

MORTALITY IN SCOTLAND: A COMPARISON OF URBAN AND RURAL AREAS.

1. CRUDE DEATH-RATES.

In order to present a rough picture of mortality in the various urban and rural districts of Scotland since 1855, the crude death-rates have been brought together in Table X, and are illustrated in Diagram 3. The figures in the table are the unweighted averages of the rates for groups of three years, taken from the Annual Reports of the Registrar-General for Scotland. (An exception is the second set of figures for 1911, where the average is over two years.) The three-year periods, with the exception of the first and last, are centred at Census years.

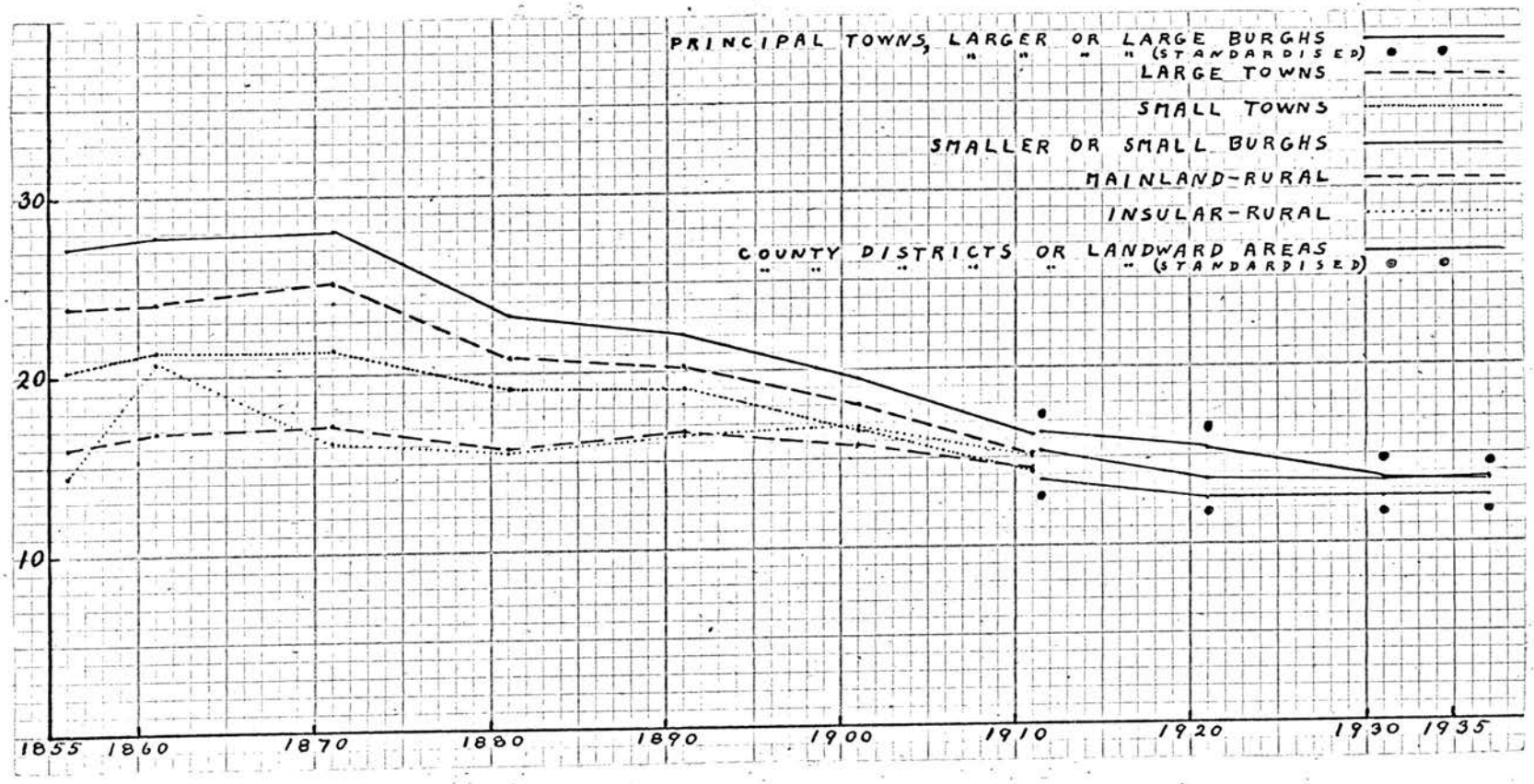


Diagram 3. Mortality in the Urban and Rural Divisions of Scotland: crude Death-Rates from 1855-57 to 1936-38; Death-Rates standardised by the Indirect Method from 1911-12 to 1936-38.

TABLE X.

Mortality in the Urban and Rural Divisions of Scotland: Crude Death-Rates from 1855-57 to 1936-38; Death-Rates standardised by the Indirect Method (in brackets) from 1911-12 to 1936-38.

	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	SCOTLAND
1855-57	27.2	23.9	20.3	16.0	14.4	20.3
1860-62	27.8	24.0	21.4	16.9	20.6	21.4
1870-72	28.0	25.1	21.4	17.2	16.1	22.2
1880-82	23.2	20.8	19.1	15.7	15.6	19.7
1890-92	22.0	20.2	19.0	16.7	16.6	19.7
1900-02	19.5	18.0	16.6	15.8	16.8	17.9
1910-12	16.1	15.2	14.1	14.3	15.0	15.2
	Larger Burghs	Smaller Burghs	County Districts			
1911-12 a	16.3 (17.4)	15.3 (14.9)	13.7 (12.8)			15.2
1920-22	15.4 (16.5)	13.7 (13.2)	12.6 (11.8)			14.2
	Large Burghs	Small Burghs	Landward Areas			
1930-32 b	13.7 (14.7)	13.6 (12.6)	12.6 (11.7)			13.4
1936-38	13.6 (14.5)	13.7 (12.5)	12.6 (11.8)			13.3

Rates referring to years earlier than 1871, for the five divisions of the country created in that year, were published in the Seventeenth Detailed Annual Report (Abstracts of 1871).

Rates from 1911 (second set) onwards, both crude and standardised, are "corrected for transfers" (see p. 57).

Death-rates standardised by the indirect method are placed within brackets beneath the corresponding crude rates.

a. Two-year period.

b. The rates for the period 1930-32 are the averages of the 1930 figures for Larger Burghs, Smaller Burghs and County Districts, and of the 1931 and 1932 figures for Large Burghs, Small Burghs and Landward Areas.

The diagram clearly brings out the fact that the crude death-rate has always been higher in the town than in the country, and that it increases as we pass from the Small to the Large Towns, and from the Large to the Principal Towns. During most of the period under review the death-rate has been falling, and this fall has been accompanied by a tendency for the difference between the mortality in the various groups of towns to decrease. The difference between town and country mortality has decreased still more. Such comparisons, however, are complicated by the fact that in 1911 there is a break in continuity. It was then (see p. 23) that the Registrar-General introduced his new method of classifying town and country districts. The former Principal Towns, with the addition of Ayr, Clydebank, and Falkirk, became known as Larger Burghs. The Smaller Burghs, we have decided, may be adopted, for statistical purposes, as successors to the Large Towns. As already mentioned, there is, unfortunately, a fundamental difference between the new County Districts and the old Mainland-Rural, the former including a proportion of small towns not having the legal status of burghs. Crude rates for both systems of classification are available in 1911, and there is little difference between the rates for Principal Towns and Larger Burghs, or between Large Towns and

Smaller Burghs. The largest discrepancy occurs in the country, where there is a change of death-rate from 14.3 in Mainland-Rural to 13.7 in County Districts. The comparison, however, is complicated by another change which was made in 1911; after this date the practice was adopted of transferring deaths, when necessary, from the district in which they occurred and were registered, to the district of usual residence, and the second set of figures given for 1911 (and all the figures for subsequent periods) have been adjusted in this way.

For the periods up to 1900-02 no standardised death-rates appear to have been calculated, but death-rates standardised by the indirect method are available for the period 1911-12 and subsequently. These also are included in Table X and Diagram 3. The method by which these rates have been calculated only allow comparisons to be made between different areas at the same time. They are not valid for making comparisons of secular trends. They are, however, of use in showing that the difference between town and country mortality is, in reality, larger than the crude figures would suggest. It has not been thought necessary to calculate rates standardised directly by means of a standard population, such as would be suitable for an investigation of the secular trends in

the death-rates, because the whole problem will be examined from a different and, we believe, more satisfactory angle in section 2. This new method, however, may be thought to be somewhat indirect, and it is useful to have at hand the elementary information regarding crude death-rates provided by the table and the diagram.

In the following two sections attempts will be made to evaluate the healthiness of the environment by two different methods: the first method makes use of the generation mortality coefficient instead of the standardised death-rate; in the second, the infantile death-rates of the various groups are compared. There are reasons for believing that the generation mortality coefficient is an index of the healthiness of the environmental conditions as they affect the young, whilst the infantile death-rate may be expected to reflect the environment to which the child is subjected during its first year of life; these points will be discussed more fully later.

2. GENERATION MORTALITY COEFFICIENTS.

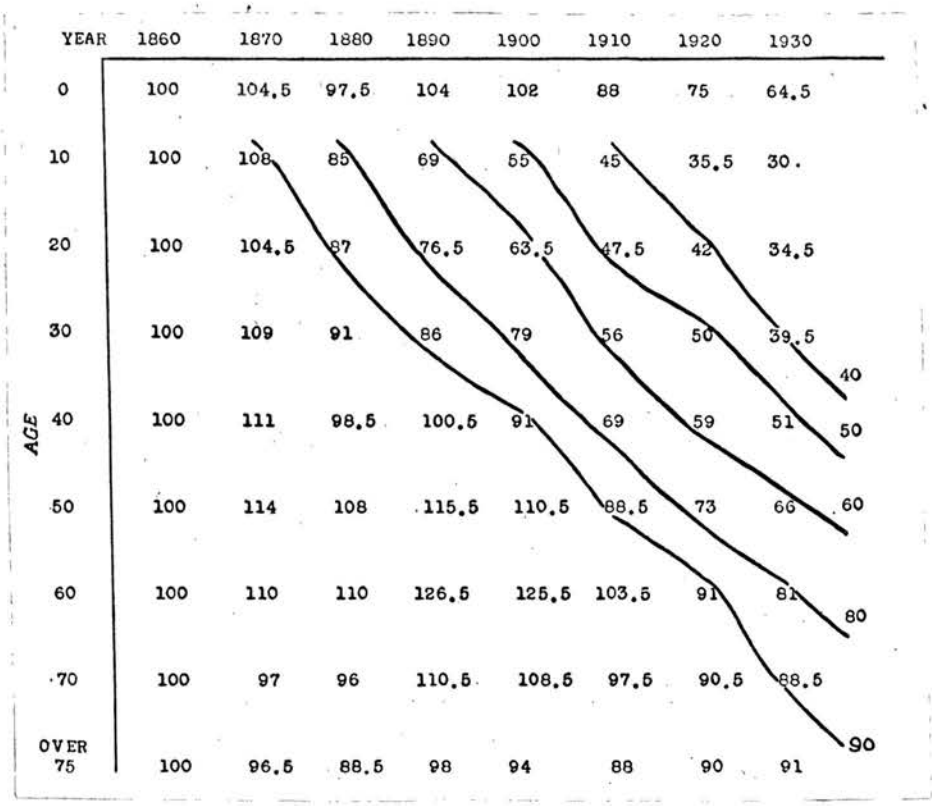
(a) Preliminary - The "Diagonal Law".

If the table of specific mortality rates for Scotland given on page 31 is examined, it will be seen that the first indication of a decline in the death-rate appears in the triennial period 1880-82. The specific rates for various ages are more or less constant before that date. If we express the rates for 1870-72 and succeeding periods as percentages of the corresponding specific rates for 1860-62, we obtain the set of "relative specific death-rates" given in Table XI, reproduced from Kermack, McKendrick, and McKinlay's first paper (1934a), already referred to (see page 40). As this table was intended to bring out only general tendencies, without emphasis on details or small variations, it was based on the mean of the figures for males and females. Also, for the age-group 5-15, centred at 10, the simple mean of the rates for the age-groups 5-10 and 10-15 was taken. As is shown below, only the ratios are important, and, consequently, slight errors involved will largely be eliminated.

TABLE XI.

Relative Specific Death-Rates, Scotland, 1860-62 to 1930-32.

AGE \ YEAR	1860	1870	1880	1890	1900	1910	1920	1930
0	100	104.5	97.5	104	102	88	75	64.5
10	100	108	85	69	55	45	35.5	30.
20	100	104.5	87	76.5	63.5	47.5	42	34.5
30	100	109	91	86	79	56	50	39.5
40	100	111	98.5	100.5	91	69	59	51
50	100	114	108	115.5	110.5	88.5	73	66
60	100	110	110	126.5	125.5	103.5	91	81
70	100	97	96	110.5	108.5	97.5	90.5	88.5
OVER 75	100	96.5	88.5	98	94	88	90	91



Superficial observation of the figures shows that, apart from small fluctuations of a more or less accidental character, they exhibit a certain regularity - along each diagonal the figure is approximately constant. The contours sketched out in the table - corresponding to relative death rates of 90, 80, 60 ... per cent., show a remarkable tendency to follow the diagonals. The result holds for all groups from the

age of five years and upwards; the death-rate under one year follows a different course, and will be discussed more fully in section 3.

It is now to be noted that a diagonal line in the diagram represents the course of a group of people all born in a particular year. Thus, the figures along a diagonal, approximately constant in value, represent the relative rates experienced by a particular group, or generation, of individuals all born in a particular year, as they pass through successive stages in their lives. The average value of the relative death-rates taken along a particular diagonal for a particular generation, at all periods of life over five years of age, may be called the "generation relative mortality". Generation relative mortalities thus calculated from the rates in Table XI, for the generations born in 1850, 1860 ... 1890, are set down in Table XII.

TABLE XII.

Generation Relative Mortalities, Scotland, 1850 to 1890.

Year of Birth	Generation Relative Mortality
1850	98.9
1860	91.4
1870	77.3
1880	62.7
1890	50.9

It will be seen that the fall is well established for the generation born in 1860, and that the rate has dropped to about 50 per cent. for that born in 1890.

This principle, conveniently referred to as the "Diagonal Law", implies that the chance of an individual dying depends on two factors, the one involving only his age, the other only the date of birth. We may regard the age factor as expressing an inherent constitutional characteristic of the race; it is the same for all generations, whatever the date of birth. The other factor depends on the date of birth, and must clearly be fixed for each generation by the time it has reached the age of 15, for the mortality experienced between the ages of 5 and 15 is sufficient to determine the value of the factor. Now this factor has been constantly getting smaller during the past eighty years, and, in as far as improvements in death-rates reflect an increase in healthiness of the community, the factor can reasonably be taken as reflecting this increasing healthiness. But, as we have remarked, the healthiness and improved environment must have been reflected in this factor by the time the generation was 15 years old. In other words, the factor must be taken as a reflection of the environment between the ages of 5 and 15.

From the present point of view, the death-rates of the older age-groups are little affected by their present environment, but seem to have been determined very largely by the environment which that particular generation experienced in childhood. Thus, in as far as they contribute to the death-rate, even to a standardised death-rate, they reflect the environment, not as it is now, but as it was several decades ago.

It is suggested, therefore, that for a proper appraisement of the environment at any particular period, it is best to take the generation relative mortality for the generation which passed its childhood in that period. From this point of view, the figures shown in Table XII are measurements of the healthiness of the environment of Scotland as a whole, at dates about ten years after the dates of birth given, that is, when the generations in question were about 10 years old.

On the basis of these considerations it was decided to attempt to compare the environment of town and country, in respect of health conditions, by the use of the generation relative mortality. A difficulty, however, is encountered in comparing two different areas with each other, which is not met with when comparing the same area at different times. In order to state this difficulty precisely, it is

convenient to enunciate the general principle of the Diagonal Law in a somewhat different form. A little consideration shows that the Diagonal Law is equivalent to the statement that the specific death-rate $f_{t,\theta}$, for age θ at time t, can be expressed as the product of two factors, β_θ and $\alpha_{t-\theta}$, where β_θ depends on the age alone, and $\alpha_{t-\theta}$ depends only on $t-\theta$, the year of birth. As stated in the chapter on definitions (cf. p.40), $\alpha_{t-\theta}$ has been called the generation mortality coefficient, and involves an arbitrary factor in the sense that, if we replace α by $k\alpha$ and β by β/k, we do not alter the value of $f_{t,\theta}$. If we are limiting ourselves to one county or area, then, if we replace each β by β/k, the result is merely to multiply all the α's by k, and the relative values of the α's remain unaffected, so that time trends are not disturbed. If, however, we are comparing two different areas, then each area will have its own set of β values, and each set will involve an arbitrary factor k_1, k_2, respectively. The two sets of α values depend, one on k_1, the other on k_2, and so cannot be directly compared. In order that the α values should be comparable, the β values ought, strictly speaking, to be identical for the two areas. In practice, however, they usually cannot be made exactly identical by the help of the arbitrary factor, because they do not

come out with exactly the same ratios to each other. We therefore make them as nearly equal in magnitude as possible, by introducing, for each set, a factor such as will result in their products having some predetermined and constant value. The natural and most convenient value to take is unity; in other words, given any set of β values, we "normalize" this set by dividing each β value by a factor k, so chosen that the product of the resulting set of values is unity. It is easily seen that k is the geometric mean of the original set of β values. When the β values have been normalized in this way, the α values which result, the "normalized" α values, are called the generation mortality coefficients.

It is these coefficients, obviously equivalent to the generation relative mortalities, which we propose to use for our comparison of the healthiness of town and country environments.

With these introductory remarks, we shall now proceed to examine the trends of mortality rates in town and country respectively.

(b) Specific Death-Rates and Relative Specific Death-Rates in Town and Country.

In the tabulation of specific mortality rates for town and country separately, certain technical difficulties are encountered which are for the most part

the result of the changes which have been introduced at various times by the Registrar-General in the classifications employed in his Annual Reports.

The main troubles arising in this way are due to the alterations in the size and character of the different urban and rural districts, already described in detail in Chapter II. Briefly, it was decided to count as "Town" population, from 1871 to 1900 the Principal Towns with over 25,000 inhabitants; from 1901 to 1930 the Principal Towns (or Larger Burghs) over 30,000; and from 1931 onwards the Large Burghs over 20,000, plus Arbroath. For the "Country" population we have taken during the period from 1871 to 1910 the Mainland-Rural Districts, from 1911 to 1930 the County Districts, and from 1931 onwards the Landward Areas. It will be seen that the intermediate group of what may be called small towns has been completely excluded from our present analysis. Previous to 1871 the available information could only be divided into Town and Rural and the consequent impossibility of separating the smaller towns makes the change from 1870 to 1871 a substantial one of such importance that it can scarcely be neglected.

Up to 1910 the age groups tabulated by the Registrar-General are 5-10, 10-15, 15-20, 20-30, 30-40, etc. From 1911 onwards they were 5-10, 10-15, 15-25, 25-35,

35-45, etc. For our purposes the figures for the age groups 5-15, 15-25, 25-35, etc., were obtained by a process of averaging.

Up to 1910 the rates for males and females were given separately; from 1911 onwards the figures for both sexes combined are alone available. For the earlier periods a process of simple averaging was employed to obtain the "total" rates (i.e., for both sexes combined).

The largest anomaly caused by the changes occurring at various periods in the definitions of town and country is avoided by excluding all years previous to 1871. The mortality rates for the various Census years have been calculated by taking the mean of the three successive years centred round the Census year in question, in order to reduce transient irregularities. An exception is the first Census period, 1871, the figures for which are based on only two years, 1871 and 1872, in consequence of the 1870 rates having to be omitted. Specific death-rates for town and country separately are not available for the triennial period centred at 1941. The remaining variations in classification are unfortunate, but it is unlikely that the errors introduced are sufficiently large to influence the final results appreciably.

The rates upon which the present analysis is

based are presented in Tables XIII and XIV. These are not strictly accurate, as they are obtained in some instances by the process of averaging referred to above, but the errors introduced in this way are relatively small.

TABLE XIII.

Specific Death-Rates, Town, 1871 to 1931.

Age	1871	1881	1891	1901	1911	1921	1931
10	10.9	7.9	5.8	4.4	3.7	2.6	2.4
20	10.27	8.1	6.6	5.4	3.9	3.6	3.1
30	13.65	10.4	9.8	8.5	6.0	5.3	4.0
40	18.2	15.0	14.9	13.3	9.8	8.1	6.5
50	26.55	23.3	24.5	23.1	17.5	15.3	11.3
60	43.5	40.1	43.9	42.8	34.3	33.0	24.2
70	80.8	73.2	83.3	79.7	71.4	69.0	61.3

TABLE XIV.

Specific Death-Rates, Country, 1871 to 1931.

Age	1871	1881	1891	1901	1911	1921	1931
10	4.8	4.0	3.7	2.9	2.4	2.1	1.9
20	7.0	5.8	5.5	4.9	3.8	3.4	2.8
30	8.6	7.5	7.7	6.9	5.4	4.4	3.7
40	9.1	8.7	9.3	8.9	7.3	6.0	5.4
50	12.8	12.3	13.7	13.9	11.8	9.8	8.8
60	23.3	23.1	26.6	27.4	24.2	22.3	19.0
70	53.5	52.8	60.1	59.1	52.3	46.7	47.5

The next step in the analysis is to calculate all rates as percentages of those existing in what we

have called the standard period. This standard period is supposed to give the rates which obtained before the fall which has characterized recent decades had set in. The choice of the years 1871-72 as the standard period is justified by the facts (1) that for the whole of Scotland the specific mortality rates showed little or no change up to and including 1871, and (2) that for both town and country the year 1870 showed no fall as compared with the three-yearly period 1860-2, but if anything a slight rise. The rates as percentages of the standard are shown in Tables XV and XVI.

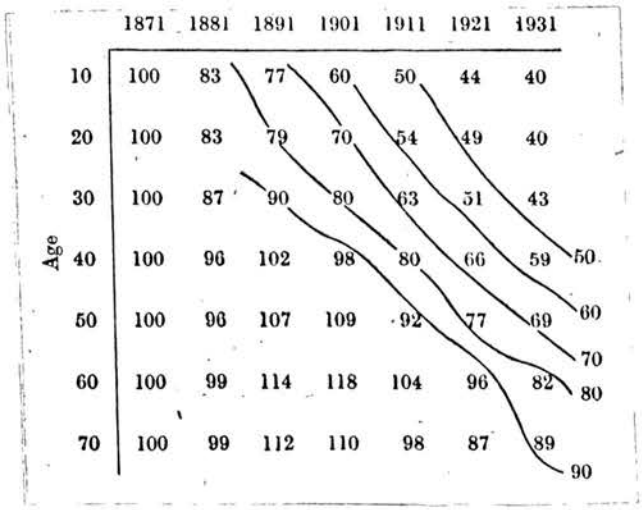
TABLE XV.

Relative Specific Death-Rates, Town, 1871 to 1931.

Age	1871	1881	1891	1901	1911	1921	1931
10	100	72	53	40	34	24	22
20	100	79	64	53	38	35	30
30	100	76	72	62	44	39	29
40	100	82	82	73	54	45	36
50	100	88	92	87	66	58	43
60	100	92	101	98	79	76	56
70	100	91	103	99	88	85	76
80							

TABLE XVI.

Relative Specific Death-Rates, Country, 1871 to 1931.



Age	1871	1881	1891	1901	1911	1921	1931
10	100	83	77	60	50	44	40
20	100	83	79	70	54	49	40
30	100	87	90	80	63	51	43
40	100	96	102	98	80	66	59
50	100	96	107	109	92	77	69
60	100	99	114	118	104	96	82
70	100	99	112	110	98	87	89

Inspection shows that for the country (Table XVI) the figures along the dextro-diagonals are approximately constant. The lines in the figure indicate the positions of the 90,80, 70%, etc., contours, and these as will be seen are approximately straight, and at an angle of 45° to the vertical. In the case of the towns (Table XV), similar results are obtained. The uniformity, however, is not quite so great, the chief disturbance being caused by a fall between 1871 and 1881 which is not confined to the lower age-groups. This deviation from regularity in the case of the towns suggests that some of the 1871 rates may be unduly high. In order to control this point calculations were carried out from the data, omitting the 1871

values. No standard rate being now available, an alternative procedure was followed. This was first described by Kermack, McKendrick, and McKinlay (1934b), and will now be briefly explained.

A set of β values, as we have remarked before, includes an arbitrary factor. The ratios between the different values, however, are fixed, and a little consideration will show that estimates of these ratios may be obtained by calculating the ratios between the different specific death-rates along a diagonal. This is a consequence of the Diagonal Law; if we assume that $f_{t,\theta} = \beta_\theta \alpha_{t-\theta}$, then $\frac{f_{t,\theta}}{f_{t-10,\theta-10}} = \frac{\beta_\theta \alpha_{t-\theta}}{\beta_{\theta-10}\alpha_{t-10-\theta+10}} = \frac{\beta_\theta}{\beta_{\theta-10}}$. For example $\frac{f_{1921,20}}{f_{1911,10}}$ gives an estimate of $\frac{\beta_{20}}{\beta_{10}}$. Another estimate of $\frac{\beta_{20}}{\beta_{10}}$ is got from $\frac{f_{1911,20}}{f_{1901,10}}$. Thus by keeping to the same two rows in a table, taking different values of t and the same values of θ, we get a number of estimates of $\frac{\beta_{20}}{\beta_{10}}$, and the average of these is taken as the best value of the ratio. Similarly, estimates of $\frac{\beta_{30}}{\beta_{20}}$, $\frac{\beta_{40}}{\beta_{30}}$, etc., may be obtained, and, by giving β_{10} the arbitrary value of unity, a complete set of β's is readily calculated.

The results of applying this method to the town specific death-rates in Table XIII (omitting the somewhat anomalous 1871 values) are found to be in substantial agreement with those obtained by the first or "standard rate" method. For sake of completeness the

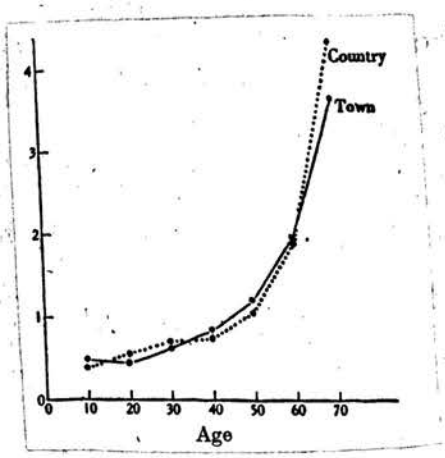


Diagram 4. Normalized β Values for Town and Country, calculated by First or Standard Rate Method.

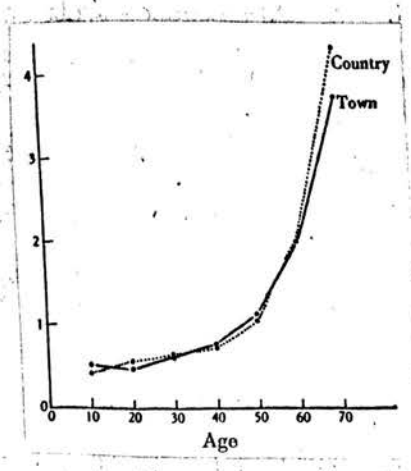


Diagram 5. Normalized β Values for Town and Country, calculated by Second Method.

country figures have also been worked out by the second method; here the 1871 figures are not excluded.

(c) Generation Mortality Coefficients.

For purposes of comparison, as we have pointed out, it is necessary to normalize each set of β values, that is, to divide each set by a factor (its geometric mean), so that the product of the β's so normalized is unity. The α values corresponding to these normalized β values are then calculated. The normalized β values for town and country, calculated both by the first or standard rate method and by the second method, are given in Table XVII, and the corresponding generation mortality coefficients (normalized α values) in Table XVIII. Curves illustrating these figures are shown in Diagrams 4, 5, 6, and 7.

TABLE XVII.

Normalized β Values for Town and Country, calculated both by First or Standard Rate Method and by Second Method.

	Town		Country	
Age	First Method	Second Method	First Method	Second Method
10	.492	.509	.391	.417
20	.464	.489	.571	.554
30	.617	.596	.701	.646
40	.822	.779	.742	.733
50	1.200	1.161	1.043	1.045
60	1.965	1.990	1.899	2.008
70	3.651	3.762	4.360	4.369

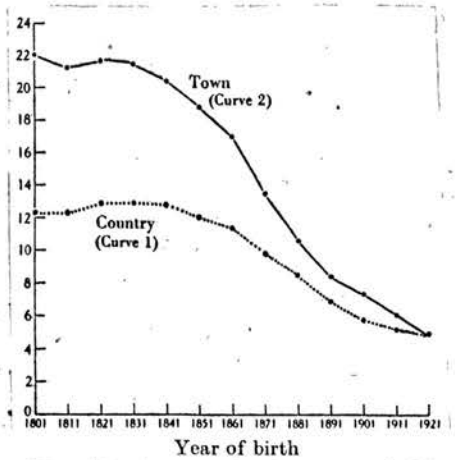


Diagram 6. Generation Mortality Coefficients (normalized α Values) for Town and Country: First or Standard Rate Method. Note: In interpreting Diagrams 6, 7, and 8, it is to be remembered that the date given is the date of birth of the generation, and not that of the period, about 10 years later, of which the generation mortality coefficient reflects the social environment.

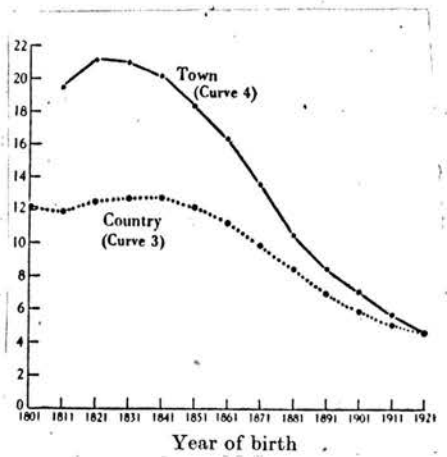


Diagram 7. Generation Mortality Coefficients (normalized α Values) for Town and Country: Second Method. See Note to Diagram 6.

TABLE XVIII.

Generation Mortality Coefficients (normalized α Values) for Town and Country, calculated both by First or Standard Rate Method and by Second Method.

	Town		Country	
Year of Birth	First Method	Second Method	First Method	Second Method
1801	22.1	-	12.3	12.2
1811	21.2	19.5	12.3	11.9
1821	21.7	21.2	12.8	12.5
1831	21.5	21.1	12.9	12.7
1841	20.4	20.2	12.8	12.8
1851	18.8	18.4	12.0	12.2
1861	17.0	16.4	11.4	11.3
1871	13.5	13.6	9.8	9.9
1881	10.6	10.5	8.5	8.5
1891	8.4	8.5	6.9	7.0
1901	7.3	7.1	5.8	5.9
1911	6.0	5.7	5.2	5.1
1921	4.9	4.7	4.9	4.6

So far the data for town and country have been considered independently. The next step is to compare the town generation mortality coefficients with those of the country, in order, if possible, to obtain information as to the relative healthiness of urban and rural environments. We have already suggested that the β curves may be regarded as reflecting the physiological constitution of the population as a function of age, whilst the α curve is a measure of the influence of the environment. This statement requires a slight qualification, for it seems clear that if the

environment is such as to affect peculiarly some one particular age-group, this fact will be reflected in the shape of the β curve. We have in fact to regard the β curve as reflecting the relative viabilities of the population at different ages in the economic and social conditions existing during the whole period under examination. The existence of the Diagonal Law shows that the shape of the β curve from 10 years of age upwards is approximately the same for all generations, from which it is inferred that the major effect of the environment is exerted during childhood, largely before the tenth year of age. Thus the generation mortality coefficient (α value) is a measure of the general level of the environment during childhood, the period during which the general constitution of the individual is being built up. If the individuals in the towns were entirely unrelated to, and innately different in vigour from, the individuals in the country, no comparison between the mortality rates would shed light on the state of the environment, but it seems reasonable to assume that the mean innate vigour of the individuals in the towns is the same as that of the country population. The plausibility of this is increased by the consideration that the town population has within recent generations been largely derived from the surrounding country, so that the

genetic constitutions of the two groups cannot differ very greatly.

The use of the normalized β values (where the product, and therefore the geometric mean, of the β's is always unity) automatically ensures the equality of the geometric means, and so the corresponding generation mortality coefficients are directly comparable. In other words, when the normalized β's are used, the corresponding generation mortality coefficients may be compared without further adjustment. The object of this argument has been to show that environmental conditions in town and country may be compared by the use of the α values; these α values may be derived either by the first or standard rate method (Diagram 6), or by the second method (Diagram 7). The corresponding curves in Diagrams 6 and 7 are, in fact, very similar, so that any conclusions to be drawn are practically independent of the method of analysis employed.

A comparison of the environmental conditions in town and country may be conveniently represented by the ratios of the corresponding generation mortality coefficients. These ratios are given in Table XIX and shown in curves 5 and 6 in Diagram 8. The substantial agreement of these two latter curves again shows that the result is practically independent of

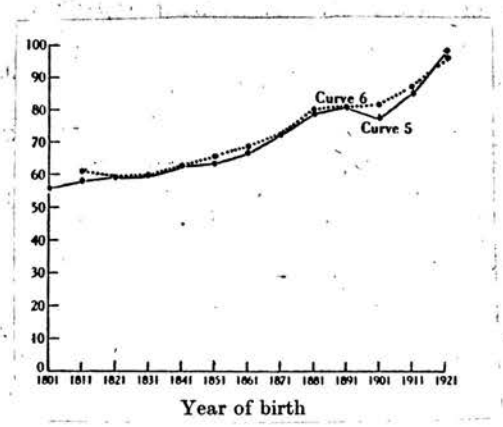


Diagram 8. Percentage Ratios of Country Generation Mortality Coefficients to Town Generation Mortality Coefficients: Curve 5 (full line) calculated by First or Standard Rate Method, Curve 6 (dotted line) calculated by Second Method. See Note to Diagram 6.

the precise method of analysis employed.

TABLE XIX.

Percentage Ratios of Country Generation Mortality Coefficients to Town Generation Mortality Coefficients, calculated both by First or Standard Rate Method and by Second Method.

Year of Birth	First Method	Second Method
1801	56	-
1811	58	61
1821	59	59
1831	60	60
1841	63	63
1851	64	66
1861	67	69
1871	73	73
1881	80	81
1891	82	82
1901	79	83
1911	87	89
1921	100	98

(d) Discussion.

The above analysis of the mortality statistics for the urban and rural districts of Scotland shows that in both these divisions the same regularities are observed as for the whole population. The level of the mortality rates, especially in the past, has been different in the two areas, but the changes which have occurred have been similar and approximately in accordance with the Diagonal Law. It was perhaps scarcely to be expected that the degree of accordance

would be as good as for Scotland as a whole, because during the period under consideration, large movements of population have undoubtedly taken place. There has been much migration from rural to urban areas, and in addition considerable immigration from Ireland to certain parts of Scotland - chiefly, it would seem, to urban areas. Emigration has also been considerable, but this has affected the whole nation, and has not acted differently on the two divisions of the community which we are comparing. With the statistics at present available it would be difficult to make adequate allowance for such migratory movements of the population. Furthermore, it should perhaps be pointed out that the separation of the two populations representing town and country respectively is to some extent an arbitrary one, dependent on peculiarities of local administration. The fact that the intermediate groups of small towns have been omitted helps, however, to ensure that the two populations analysed are in sufficient contrast and represent broadly town and country conditions.

It is natural to enquire to what extent inferences can be drawn from the above analysis in regard to the relative "healthiness" of town and country. It should be pointed out that the idea of the "healthiness" of a particular environment is a somewhat vague

one, as the manner in which an environment affects health may depend on the age or the innate constitution of the population subjected to it. However, it will be generally conceded that an environment which results in a high death-rate is an unhealthy one. We may then take the level of the death-rates in a community as an indication of the healthiness, or rather the unhealthiness of the environment, provided that there is no reason to believe that there is any substantial variation in the genetic constitution of the populations in question, and provided also that suitable allowance is made for differences of age and, if necessary, of sex. The analysis we have undertaken, based as it is on specific mortality rates and not, for example, on total death-rates, is independent of any age differences there may be in the two populations under investigation. The data do not allow of the two sexes being considered separately, but it seems scarcely likely that the effect of environment on the two sexes would be sufficiently different to make it necessary to analyse separately in respect of this factor.

It is not easy when confronted with the two complete sets of specific mortality rates for various age-groups and for various calendar periods - one for the town and the other for the country - to see how

best to obtain some measure of their relative levels. The ratios of the corresponding rates for town and country may differ widely according to the age and calendar period. It is here that our analysis of the rates into the component α and β values proves especially useful. We have already given reasons for believing that the set of β values is, broadly speaking, a reflection of the physiological changes produced by age, whilst the generation mortality coefficient is a measure of the social conditions which existed during the childhood of the generation. Thus if we want to compare the relative conditions in town and country in, say 1890, we simply compare the generation mortality coefficients belonging to the two groups - town and country respectively - who were in their childhood at that time, that is, those who were born some 10 years previously, say in 1880. Naturally one cannot be absolutely precise with regard to the extent of the interval. Although of course one is not justified in correlating in a quantitative sense the numerical value of α with the essentially vague idea of healthiness, it nevertheless seems justifiable for purposes of comparison to adopt this value as an indication of the environmental conditions. Consequently the ratios of the corresponding generation mortality coefficients presented in Diagram 8 give

some indication of the relative conditions in town and country at the different calendar periods. In interpreting this diagram, and also Diagrams 6 and 7, it is necessary to remember that the dates given are dates of birth, and that the social environment reflected by the mortality rates is that of some 10 years later. On this basis it will be seen from Table XIX and Diagram 8 that up to about 1851 the relative healthiness of town was about 60% of that of the country. About that time the ratio began to increase, but only very slowly, reaching 70% 30 years later (about 1881). After a delay between 1891 and 1911 the increase has continued at a somewhat accelerated pace, with the result that about 1931 the ratio was in the neighbourhood of 100%. In other words, our analysis appears to indicate that the real healthiness of the town environment has by now become approximately equal to that of the countryside. This gives a verdict rather more favourable to the town at the present day than the mere inspection of the crude and standardised death-rates might have suggested (cf. Table X). However, as the conception of healthiness in town and country is a somewhat vague one, the generation mortality coefficient must be taken as a general indication rather than as an exact quantitative measure. We therefore conclude that the

relative healthiness of the town is now at roughly the same level as that of the country. The balance of advantage may still be with the latter, but if so, it cannot be very great.

It is of interest to compare the ratios of the generation mortality coefficients in town and country with those of the standardised death-rates. In 1911 the ratio of the standardised death-rates for country and town areas was 0.74, in 1921 it was 0.72, whilst in 1931 it was only 0.80 (cf. Table X). In other words, the mortality in the country in 1931 was on an average 20% lower than in the town. It is to be remembered, however, that much of this mortality is contributed by the relatively aged who do not seem to reflect in their health their immediate environment but rather that of their youth. In the case of both the 5-15 and the 15-25 groups the ratios have risen to over 90% since 1931.

A comparison of the town rates in 1935 with the country rates in 1931 is interesting. This is given in Table XX.

TABLE XX.

Specific Death-Rates for Large Burghs, 1935, and for Landward Areas, 1931.

Age-Groups	Large Burghs, 1935	Landward Areas, 1931
5-10	2.2	2.1
10-15	1.6	1.6
15-25	2.8	2.9
25-35	3.6	3.6
35-45	6.0	5.1
45-55	11.3	8.7
55-65	23.5	18.5
65-75	58.9	48.6

As will be seen, the corresponding rates are almost equal up to age 35, from which it may be concluded that for these younger age-groups the town conditions lagged at most only a few years behind those of the country. However, although these special comparisons are of interest as confirming our general conclusion, we attach greater importance to the trend of the figures as a whole which is revealed by the generation mortality coefficient curves shown in Diagrams 6, 7, and 8.

3. INFANTILE DEATH-RATES.

The generation mortality coefficient, we have suggested, may be regarded as a measure of the influence of environment on the health of young people between the ages of 5 and 15. The infantile death-rate (annual number of deaths under one year of age per 1000 total births), it might be supposed, reflects the environment as it affects children during the first year of life. How far this supposition is justified we shall discuss more fully later. With the object of studying this aspect of urban and rural environment and comparing the trends, the next three tables have been drawn up, giving the infantile death-rates in the various town and country districts of Scotland, together with figures for certain cities and groups of counties.

The rates for quinquennial periods presented in Table XXI are for the divisions of the country according to the usual classification, and are the simple averages of the rates for single years. In the Fifty-Sixth Report of the Registrar-General (for 1910) these are given for each year up to and including 1910. The rates from 1911 to 1943 were extracted from each Annual Report separately.

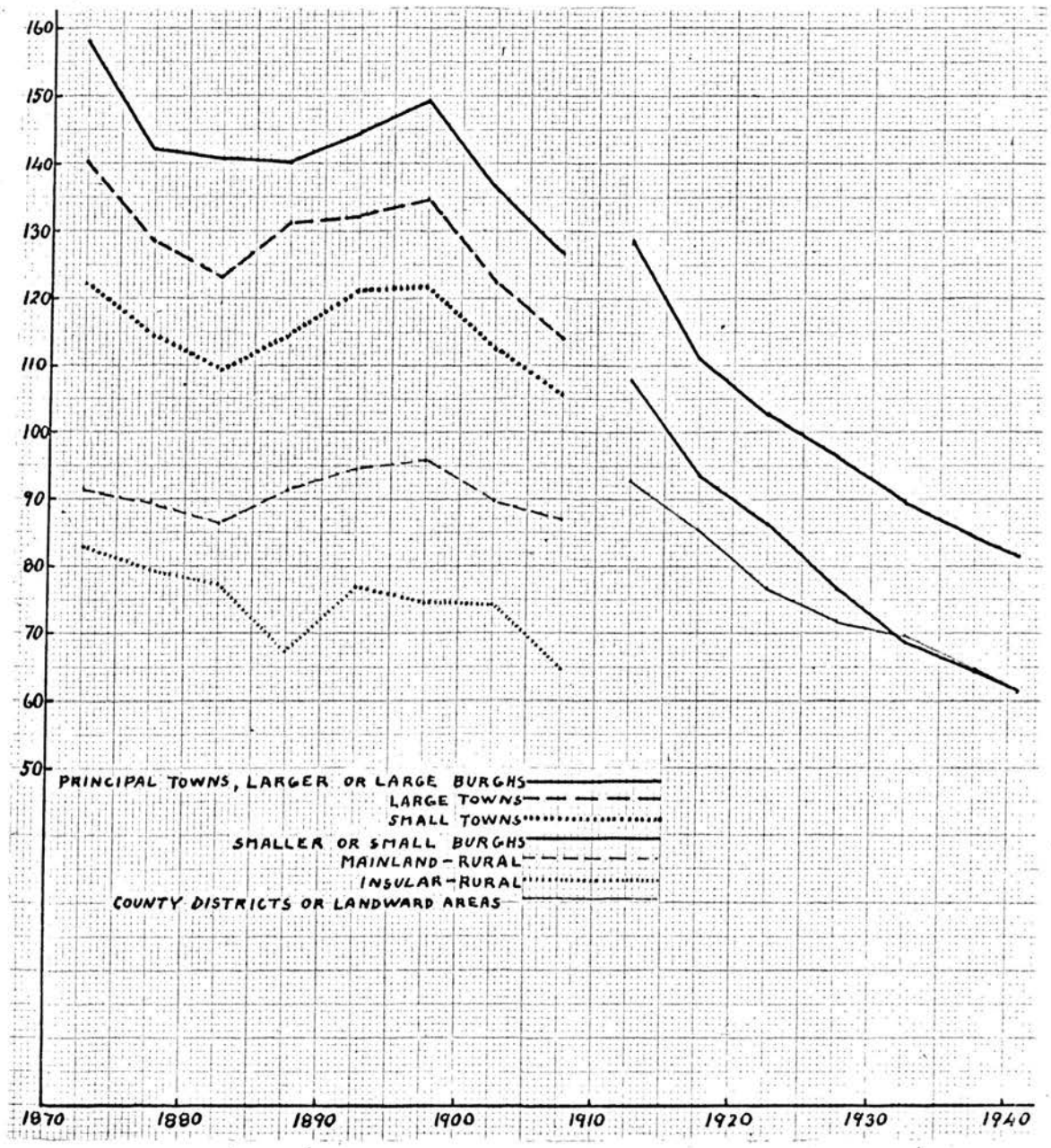


Diagram 9. Infantile Death-Rates in the Urban and Rural Divisions of Scotland, 1871-75 to 1941-43.

TABLE XXI.

Infantile Death-Rates in the Urban and Rural Divisions of Scotland, 1871-75 to 1941-43.

	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	SCOTLAND
1871-75	158.0	140.1	122.1	91.5	82.9	127.2
1876-80	142.1	128.4	114.3	89.7	79.5	118.3
1881-85	140.6	123.0	109.3	86.3	77.2	117.6
1886-90	140.0	131.1	114.6	91.3	67.2	120.6
1891-95	144.5	132.2	121.1	94.6	76.8	126.3
1896-00	149.1	134.9	121.7	95.9	74.4	129.4
1901-05	136.1	122.3	112.4	89.9	74.1	119.9
1906-10	126.5	114.0	105.6	87.0	64.8	112.3
	Larger Burghs	Smaller Burghs	Country Districts			
1911-15	128.4	107.7	92.8			112.9
1916-20	111.0	93.6	85.4			99.6
1921-25	102.7	86.3	76.6			91.8
1926-30	96.4	76.5	71.8			85.5
	Large Burghs	Small Burghs	Landward Areas			
1931-35	89.4	68.6	69.6			80.7
1936-40	84.2	64.4	64.8			75.8
1941-43	81.6	61.3	61.3			72.4

Note: The last period contains only three years.

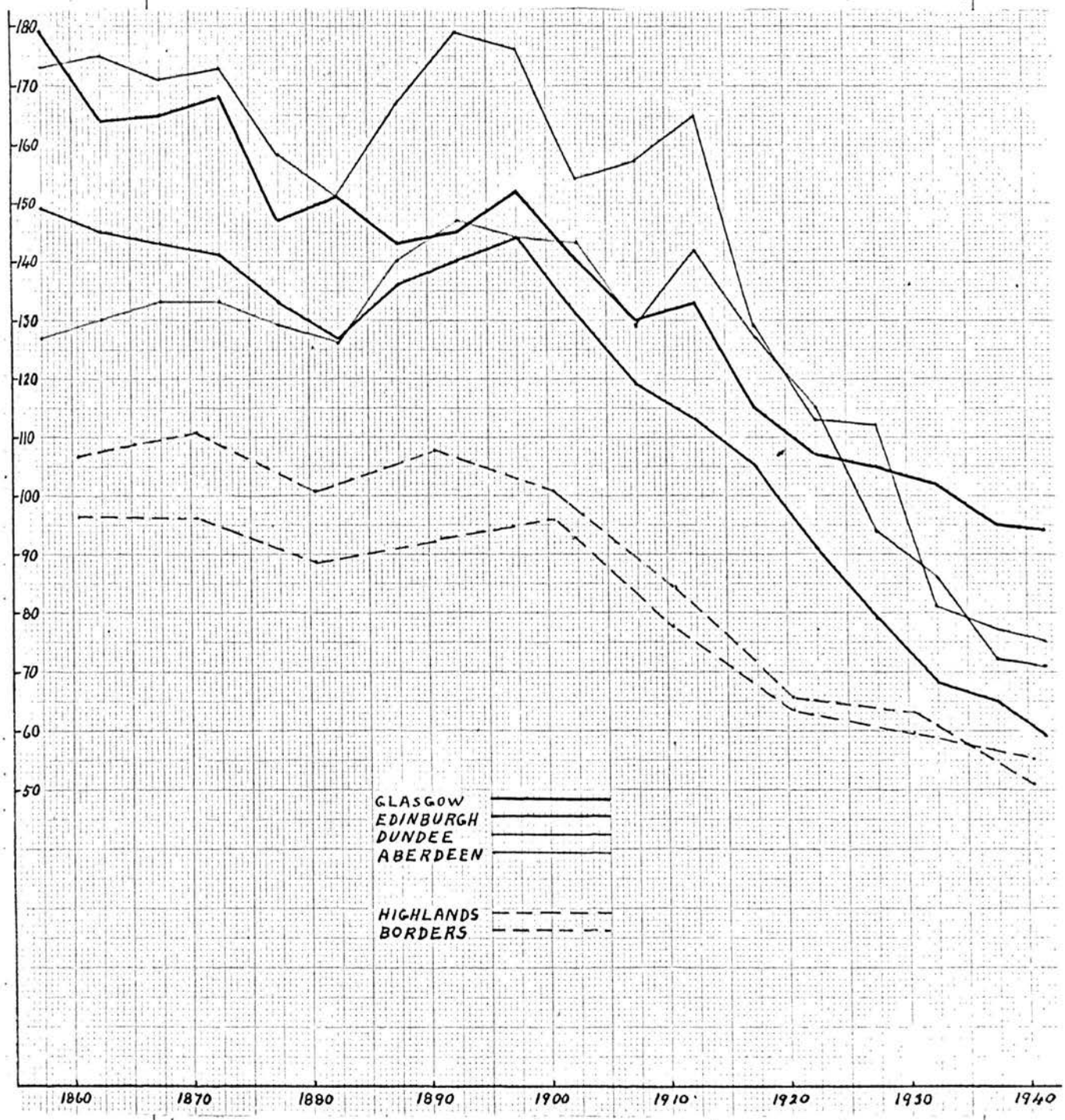


Diagram 10. Infantile Death-Rates in the Four Chief Cities of Scotland, 1855-60 to 1941-43; and in the Highlands and Borders, 1859-63 to 1939-43.

To demonstrate how infantile death-rates vary between individual cities, the rates for Glasgow, Edinburgh, Dundee, and Aberdeen are given in Table XXII. Again the averages of the rates over five years have been taken. Those for single years from 1855 to 1905 were found in the Fifty-First Annual Report (for 1905), and for 1906 to 1943 were got from the individual Reports for each year.

TABLE XXII.

Infantile Death-Rates in the Four Chief Cities of Scotland. 1855-60 to 1941-43.

	Glasgow	Edinburgh	Dundee	Aberdeen
1855-60	179	149	173	127
1861-65	164	145	175	130
1866-70	165	143	171	133
1871-75	168	141	173	133
1876-80	147	133	158	129
1881-85	151	127	151	126
1886-90	143	136	167	140
1891-95	145	140	179	147
1896-00	152	144	176	144
1901-05	140	131	154	143
1906-10	130	119	157	129
1911-15	133	113	165	142
1916-20	115	105	129	127
1921-25	107	91	113	115
1926-30	105	79	112	94
1931-35	102	68	81	86
1936-40	95	65	77	72
1941-43	94	59	75	71

The rates for Scotland as a whole are: 1855-60, 119.7; 1861-65, 119.8; and 1866-70, 122.2. Rates for later periods are given in Table XXI.

Note: The first period contains six years; the last, only three.

Finally, to bring out differences which might exist between the infant mortalities in different regions of rural Scotland, the figures in Table XXIII were calculated. This table contains two groups of counties, one of which (including Sutherland, Ross and Cromarty, Inverness, and Nairn) may be taken as typical of the Highlands, and the other (Peebles, Selkirk, Roxburgh, and Berwick) as typical of the Borders. Such a comparison is interesting because, superficially at any rate, the two groups have much in common, and neither contains any large towns. To avoid large sampling errors due to the small number of infant deaths occurring in these limited groups during a single year, the sum of the figures for five successive years was used to compute each rate. The births and infant deaths in each county for each year were abstracted from the various Annual Reports, and added up for the two groups separately before taking the ratio of deaths to births. The fertility rates for these two groups, which are discussed at some length in Chapter V, show very sharp contrasts in their trends during the past seventy years. These fertility rates involve Census data, and so are centred at Census years. In order that the mortality should be comparable with the fertility series, the former also was centred at Census years.

TABLE XXIII.

Infantile Death-Rates in the Highlands and Borders of Scotland, 1859-63 to 1939-43.

	Counties of Sutherland Ross and Cromarty Inverness Nairn	Counties of Peebles Selkirk Roxburgh Berwick
1859-63	96.3	106.7
1869-73	96.1	110.8
1879-83	88.7	100.5
1889-93	92.3	107.7
1899-03	95.9	100.8
1909-13	77.6	84.5
1919-23	63.5	65.7
1929-33	59.6	63.0
1939-43	55.2	51.0

The data in the three tables may be seen at a glance in Diagrams 9 and 10, which we may now consider. From the first diagram it will be remarked at once that throughout the period for which we have statistics the infantile mortality curves for the different types of town and country districts are widely separated. Infantile death-rates decrease rapidly as we proceed from larger to smaller towns, and even more rapidly as we pass to the country, the Insular-Rural Group being lowest of all. The only exception is that during the last decade or so the rates for Landward Areas and Small

Burghs have become practically identical, in consequence of the fall for the latter having been more rapid than that of the former.

In every group the rates decreased for 10 or 15 years after 1875 but rose again in each case, and it is only after 1900 that a significant fall appears to have set in. Improvement in infant mortality, evidently, lagged about 25 years behind general mortality, which began to fall, as we have seen, about 1875.

As in the case of the crude death-rate, there can be little doubt that infantile death-rates were much higher in this country during the eighteenth century and probably also in the first half of the nineteenth. In Sweden, for which a long record of figures is available, infant mortality stood at approximately 200 from 1750 to about 1810. Thereafter it declined more or less steadily to about 50 in 1931-35.

Reverting to Scotland, the fall in infant mortality since the beginning of the present century has been most pronounced in the urban groups. The evidence concerning the country experience is somewhat confused by the unfortunate break in continuity in 1911. It may be pointed out that the rate for Mainland-Rural in 1881-85 (86.3) is practically the same as for 1906-10 (87.0), and that the value for the country in the next quinquennial period (1911-15)

is 92.8. The last figure, however, is for County Districts, which include numerous small towns not having the status of burgh. This fact probably accounts for at least part of the rise from 1906-10 to 1911-15. But there was also a rise during the same interval from 126.5 for Principal Towns to 128.4 for the very similar group of Larger Burghs, which suggests that there may really have been a slight rise for the country as well. On the whole, the definite improvement set in in the country fully a decade later than in the towns.

A striking example of the difference between urban and rural infant mortality is that the rate for Large Burghs in 1941-43 (81.6) is higher than that of the Insular-Rural Group in 1876-80 (79.5).

A direct comparison between the effects of town and country environment on infant health during the past seventy years has been made by calculating, for each quinquennial period, the ratio of the infantile death-rate in the country to that in the town. The same groups are employed as in section 2, and the intermediate groups of smaller towns and burghs are omitted for this comparison also. The results are given in Table XXIV.

TABLE XXIV.

Percentage Ratios of Country to Town Infantile Death-Rates, 1871-75 to 1941-43.

1871-75	58
1876-80	63
1881-85	61
1886-90	65
1891-95	65
1896-00	64
1901-05	66
1906-10	69
1911-15	72
1916-20	77
1921-25	75
1926-30	74
1931-35	78
1936-40	77
1941-43	75

The figures show that town environment in 1941-43 was considerably more harmful to infant life than that of the country. This result at first sight seems to be inconsistent with our finding, based on generation mortality coefficients, that, at the present time, town and country environment are almost equally salubrious for children between the ages of 5 and 15. It may be, however, that whereas the health of the youth depends on his immediate environment, the health of the infant is dependent to a very large degree upon the general welfare and vitality of the mother. If we turn for a moment to Scotland as a whole, reference to the table on page 61 shows that in 1870 there was a substantial improvement in the generation relative

mortality. The generation of girls born about that time would become mothers between 1890 and 1900, and it was just about this time that the fall in the infantile death-rate set in. This is easily understood if the health of the very young child does, in fact, primarily depend upon the health of the mother, rather than upon the immediate social environment.

Now, from the table of generation mortality coefficients (p.73) it will be seen that improvement in general mortality is first apparent in the town, which, in this respect, appears to be a decade or thereabouts in advance of the country. Thus, if our theory is correct, the lag in the improvement in the health of country mothers behind that of town mothers, should result in a corresponding lag in the improvement of country infantile death-rates behind that of the town, and this, as we have indicated, is borne out to some extent by the trends of the curves in Diagram 9. Further, as it is only now that the influence of town environment on the health of the youth has become equal to that of the country, we cannot anticipate equality between urban and rural infantile death-rates for another decade or two, when the girls now about 10 years old are becoming mothers.

The whole picture is thus consistent with the hypothesis that the environment in early youth is the

important factor in determining the consitution of the individual, and that the health and vitality of the mother, thus developed, is of primary importance to the welfare of the infant.

The infantile death-rates for each of the four chief cities and the two groups of Highland and Border counties are outlined in Diagram 10. Both Glasgow and Dundee are very high (over 170) in the early years. Broadly speaking, the trend of the Glasgow rate is downward throughout the period, but the Dundee rate remains high until after 1910. It then declines suddenly and steeply, falling from 165 in the period 1911-15 to 75 in 1941-43. Edinburgh, on the whole, has the best record, being uniformly below the other three cities since 1900, and prior to that second only to Aberdeen. At present the infantile death-rate for Edinburgh is only slightly above that of the Highland counties. Up to 1881-85 the infantile death-rate of Aberdeen was the lowest of these four cities, but although fluctuating somewhat, it did not begin to fall definitely until after 1910. Since then it has fallen steadily, and whilst in one period (1921-25) it was actually the highest of the four, it is now below Glasgow and Dundee but still above Edinburgh.

On account of the general similarity of the Highland and Border counties, a comparison of the

trends of their infantile death-rates is interesting. Up to 1931 the Highland rates are consistently lower than those of the Borders, although the difference from 1901 onwards is not statistically significant. In 1941-43 the Border rate is actually somewhat lower than the Highland, but again the difference is not significant. As we shall see in Chapter V, the fertility experiences of these two regions are in sharp contrast, and it may be that the very great drop in fertility in the Borders as compared with the Highlands, is a factor determining the more rapid fall in the infantile mortality of the former.

CHAPTER IV.

CANCER MORTALITY IN SCOTTISH URBAN AND RURAL AREAS.

1. PRELIMINARY.

It is a well-known fact that in rural areas the mortality rate from cancer, as from many other causes of death, is appreciably below that in the urban areas. Thus, in the Supplement to the Seventy-Eighth Annual Report of the Registrar-General for Scotland, Part II, published in 1936, it is shown that for the period 1921-30 the cancer mortality rates, adjusted for age and sex, for the Landward Areas, the Small Burghs, and the Large Burghs, were respectively 1200, 1330, and 1480 per million. The Large Burghs show an excess of about 23% over the Landward Areas. It has been suggested that the urban excess may in large measure be due to more accurate certification of deaths, and it is a matter of interest to obtain some idea as to how far this factor accounts for the observed excess and how far there may be a real excess of deaths due to cancer in the more urban and industrialized areas.

In 1893 King & Newsholme suggested that differences in cancer mortality depending on inaccuracies of

certification might be brought to light by analysing the available data in respect of the various sites of the malignant growth. Certain sites, such as the breast or the buccal cavity, are relatively accessible, and diagnostic error is likely to be small. Other sites, such as the digestive tract, are more difficult to diagnose, and so it might be expected that for these sites the number of cancers reported as causes of death would vary with the accuracy of certification. King & Newsholme applied the method in order to try to ascertain whether the apparent increase in cancer as a recorded cause of death might not be due to better diagnosis, but, if the method is valid, it can obviously be applied to differences such as we are concerned with here, namely, those between urban and rural areas. If these differences are due to more accurate certification in urban areas, then it would be expected that they would be most pronounced in inaccessible, and least in accessible sites.

This method has already been applied by Russell (1931) to the cancer deaths in Scotland over the years from 1923 to 1928 inclusive. In this work, however, the analysis was carried out by whole counties, including Larger Burghs, Smaller Burghs, and County Districts. No attempt was made to separate the more rural and more urban districts of each county,

presumably because the reports of the Registrar-General for Scotland for this period do not contain the necessary data. The conclusions reached by Russell may be quoted from his summary:

"The counties possessing the best equipped hospitals have a greater amount of inaccessible cancer than might be expected to occur.... As regards the two accessible sites - breast and buccal cavity - there is no defined localization in the mortality, as the number of deaths in each county, with possibly two exceptions, Renfrew for breast cancer, Midlothian for buccal cavity, approximately follow a normal distribution."

These conclusions are in marked contrast to those reached by the Registrar-General for England and Wales in his Decennial Supplement, 1921. In this comprehensive investigation of the medical statistics for the period 1911-20 a section deals with the cancer deaths in relation to both site of tumour and geographical distribution. Among the conclusions are the following (Part III, p. cxix): "....it can scarcely be doubted that the city excess for cancers so little likely to be overlooked at the time of death as those of the buccal cavity (43% tongue and 26% jaw in 1911-20, lip 'mouth' and tonsil furnishing the rest) is a real one, and not merely a consequence of fuller recognition". He also states that "for females it

(the urban excess) is relatively high for cancer of the sex organs including the breast, though in their case the risk of oversight must be comparatively small".

From 1931 onwards the reports of the Registrar-General for Scotland contain a statement of the recorded deaths from cancer by location for the various Public Health Districts, i.e., each Large Burgh as defined in the Local Government (Scotland) Act, 1929, and each county exclusive of Large Burghs. This makes it possible to compare by sites the cancer mortality rates in the Large Burghs, representing the more urban areas, with those of the rest of Scotland. In view of the apparent inconsistencies of the conclusions derived from previous Scottish and English experience, it was considered desirable to analyse the more recent data. Furthermore, the new data, which cover the period from 1931 to 1937 inclusive, allow of comparison with the results published in the Supplement to the Seventy-Eighth Annual Report of the Registrar-General for Scotland (Part II, Tables M and N). This volume deals with the decennial period 1921-30, and, in addition to the tabular matter, it contains a useful commentary by Dr P. L. McKinlay.

2. DATA AND METHODS OF ANALYSIS.

The data employed in the present investigation have been extracted from the seven Annual Reports of the Registrar-General for Scotland from 1931 to 1937 inclusive. These reports give the number of certificated cancer deaths registered in each year, arranged according to location, sex, and age in Table 28, and according to location and Public Health District in the General Registration Summary. The locations are those employed in the Revised International Long List. Each location includes a number of particular sites, the classification being as follows:

(1) Buccal cavity, etc. Lip, Mouth, Tongue, Jaw, Salivary Glands and Parotid, Tonsils, Pharynx.

(2) Digestive organs, etc. Oesophagus and Gullet, Stomach and Pylorus, Intestine, Rectum, Anus, Liver and Gall Bladder, Pancreas, Peritoneum with Omentum and Mesentery.

(3) Respiratory organs. Larynx, Lung, Pleura, Mediastinum.

(4) Uterus. Cervix, Uterus.

(5) Other female genital organs. Ovary and Fallopian Tube, Vagina and Vulva.

(6) Breast.

(7) Male genito-urinary organs. Kidney, Bladder

and Urethra, Prostate, Testis, Penis, Scrotum.

(8) Skin. Ear, Nose, Scalp and Face, Skin.

(9) Other or unspecified organs. Pelvis and Sacrum, Rib and Sternum, Skull and Spinal Column, Arm and Leg, Thyroid, Throat, Heart, Thorax, Kidney (Females), Suprarenals, Bladder (Females), Spleen, Abdomen, Brain, Eye and Orbit, Spinal Cord, Lymphatic Glands, and Others unspecified.

To avoid ambiguity we shall use the term "site" in the rest of this study to refer to a particular site, such as lip or tongue, and the term "location" to refer to one or other of these nine groups of sites.

It was necessary to decide upon a series of geographical regions suitable for the purpose in view. The separate counties were obviously too small, for the few deaths recorded in certain of these for particular locations involve a large sampling error. The choice of areas is limited to some extent by the form in which the data are presented in the Registrar-General's Reports. In every county we are given the data for each Large Burgh and for the rest of the county (excluding Large Burghs), and it is not possible to separate the Small Burghs from the Landward Areas. The following regional groupings were ultimately decided upon:

(1) The four chief cities (Glasgow, Edinburgh, Dundee, and Aberdeen).

(2) The other twenty Large Burghs.

(3) The rest of Scotland (including Small Burghs and Landward Areas).

(4) Glasgow.

(5) Edinburgh.

(6) Dundee.

(7) Aberdeen.

(8) Northern Counties (excluding Large Burghs).

(9) West-Central Counties (excluding Large Burghs).

(10) East-Central Counties (excluding Large Burghs)

(11) Southern Counties (excluding the Large Burgh of Dumfries).

The counties in each of the four divisions are those used by the Registrar-General in the Census Report for 1931. Thus the West-Central Division includes Ayr, Dumbarton, Lanark, and Renfrew; the East-Central, Clackmannan, East Lothian, Fife, Midlothian, Stirling, and West Lothian; whilst the Northern Division includes all counties to the north and west; and the Southern Division all those to the south and east.

The general plan of the work was to calculate a series of standardised cancer mortality rates, each referring to a particular location and to a particular area. In order that significant differences might be readily recognised, estimates of standard errors have

also been recorded.

The crude death-rate, as we have already pointed out, is a very unsatisfactory index by which to measure the mortality of a disease at any particular place and time. For the present purpose of comparing the incidences of the disease in the various regions, it is most convenient to make allowance for the varying age and sex distribution of the population by applying the indirect method of standardisation referred to on page 34. The direct method is inapplicable in view of the fact that the returns in the General Registration Summary, classified in respect of both location and region, are not subdivided in respect of age and sex. Consequently it is not possible, in respect of a particular region and disease location, to calculate the specific death-rates for various age-groups. Standardisation must therefore be effected by the indirect method. For the whole of Scotland the specific death-rates for each of the nine locations can be calculated, from Table 28, for each sex at various ages. With a knowledge of the age and sex distribution of the population in each region, a factor can then be obtained for this region in respect of each location, and the standardised rate is found by multiplying the crude regional rate for the location by the appropriate factor. The actual arithmetical process

involved in this indirect method of standardisation is illustrated in the table below, where we reproduce the figures used to work out the factor for standardising the death-rate for cancer of the digestive organs, in Edinburgh, 1931-37.

TABLE XXV.

Calculation by Indirect Method of Factor for standardising the Death-Rate for Cancer of Digestive Organs, Edinburgh, 1931-37.

Age-Groups	Edinburgh Male Population, 1931 Census	Male Specific Death-Rates per million, Cancer of Digestive Organs, Scotland, 1931-37	Calculated Male Deaths (1) x (2)	Edinburgh Female Population, 1931 Census	Female Specific Death-Rates per million, Cancer of Digestive Organs, Scotland, 1931-37	Calculated Female Deaths (4) x (5)
	(1)	(2)	(3)	(4)	(5)	(6)
-25	85984	10	0.9	93840	6	0.6
25-	31580	73	2.3	38566	59	2.3
35-	25337	300	7.6	32548	255	8.3
45-	23939	1032	24.7	30258	818	24.8
55-	19641	2984	58.6	23637	2221	52.5
65-	9861	6614	65.2	14619	5227	76.4
75-	2761	9057	25.0	5357	8317	44.6
85+	245	8387	2.1	828	8070	6.7
All Ages	199,350	929	186.4	239,660	857	216.2

The standard specific death-rates used are, of course, those for cancer of the digestive organs for the whole of Scotland - for the period 1931-37. By the successive application of these to the appropriate male and female sections of the population of Edinburgh, enumerated at the 1931 Census, the total number of calculated deaths for both sexes, 402.6, is obtained, being the sum of columns (3) and (6). The ratio of this to the total Edinburgh population, 439,010, is the "calculated death-rate", namely 917.1 per million. This number when divided into the death-rate for Scotland as a whole, 863.2, similarly calculated by applying the same set of specific rates to the Scottish 1931 population, gives the correction factor, 0.9412. The crude rate for this particular disease in Edinburgh, 963, is then multiplied by this factor, finally giving the standardised rate, 906 per million.

For the purpose of comparing the figures of the Scottish report for 1921-30 with those of the period 1931-37, the former rates have been standardised on the basis of the 1934 population, by this indirect method, and the results are presented in Table XXX.

In the comparison of cancer mortality during the period 1931-37 with that of 1921-30 the equivalent average death-rate (25-65) proves a useful instrument.

This, as stated on page 35, is obtained by taking the simple average of the specific death-rates between the ages of 25 and 65.

In order to calculate the specific death-rates for the whole of Scotland, the population for various age-groups is required for each sex for the central year 1934. The estimated figures were kindly supplied to us by the Registrar-General for Scotland. For the purpose of calculating the regional correction factors the age distributions for each region are needed. These distributions for 1931 are available in the Census Report for that year. It was considered that the error resulting from the use of these regional 1931 age distributions, instead of the 1934 figures, would probably be negligible, especially as only the relative, and not the absolute, values are important. Regional populations for 1934 could, in any case, only be obtained from estimates of doubtful value, and so we had little hesitation in employing, instead, the 1931 Census figures. The crude regional rates are, of course, obtained by dividing the average number of deaths per year (1931-37) by the estimated total populations of the regions for 1934.

In locations affecting one sex only, such as the uterus, the obvious course would be to state all rates in terms of this sex alone, and not of the total

population. The published data, however, make it impossible to obtain the crude local rates except in terms of the whole population; as the local male or female populations in 1934 are not available. It can be shown, however, that the relative rates in terms of Scotland as a whole are the same, whether based on total populations or female populations alone. The same considerations apply to the breast, where the incidence in male cases is very small as compared to that in females (about 1 to 100). As a result of stating all rates in terms of persons, the four locations breast, uterus, male genito-urinary organs, and other female genital organs, will be found in the tables below to have rates approximately one-half those usually stated.

The standard errors given in the table are calculated from the approximate formula S.E. = $R/\sqrt{N}$, where R is the rate in question, and N is the number of deaths from which this rate has been calculated. This formula, in the first instance, applies to the unstandardised rates, but it is also approximately true for the standardised rates, as the sampling error in the correction factor is a relatively small one.

The results obtained are presented in Tables XXVI to XXIX and Diagrams 11 to 14. Table XXVI shows the specific death-rates for the period 1931-37 for cancer

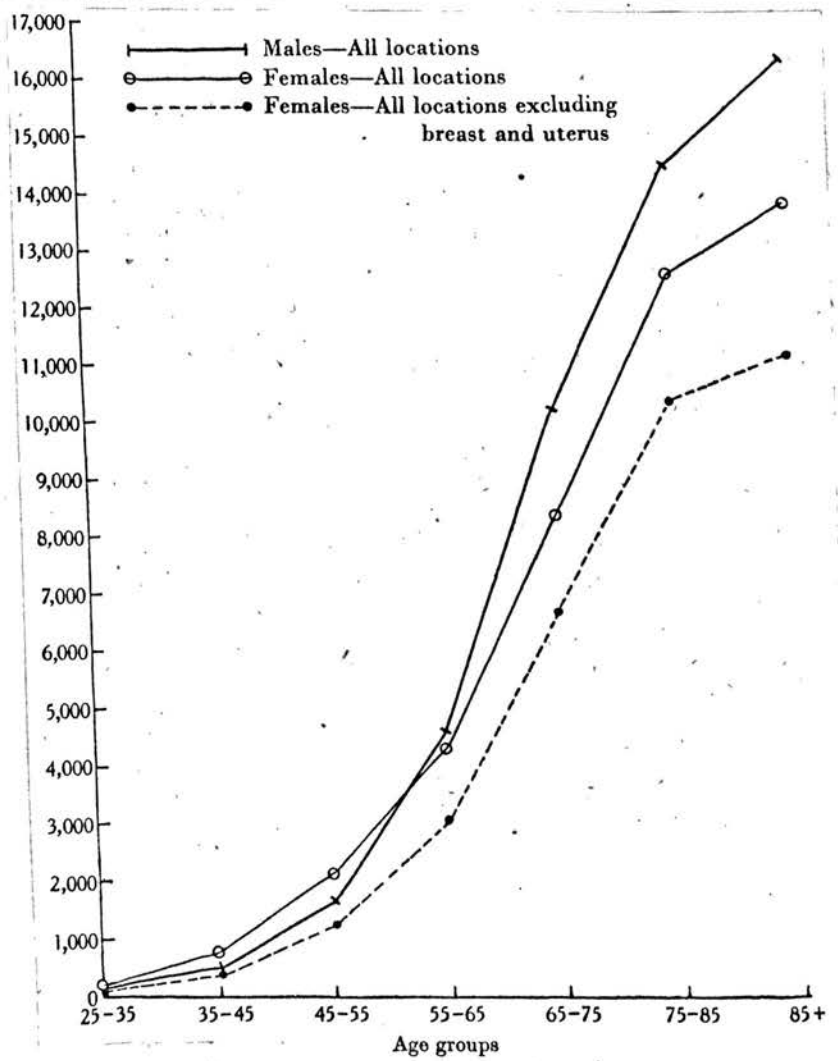
of each location, and for all locations combined, each sex being given separately. The rates for all locations combined for males and for females, and for females excluding breast and uterus, are represented graphically in Diagram 11. The principal results of the investigation are given in Table XXVII, in which will be found the standardised death-rate for each location in each of the eleven geographical regions mentioned above, as well as in Scotland as a whole. This table also contains the various regional standardising factors; these may be validly applied in analogous work over a period of years. The most important feature of this table, namely, the contrast between urban and rural areas, is illustrated in Diagram 12, in which the urban rates (the aggregate of the four chief cities) are expressed as percentages of the rural rates (Landward Areas together with Small Burghs). The changes which have occurred between the period 1921-30 and 1931-37 are shown in Tables XXVIII to XXX and Diagrams 13 and 14, the rates for 1921-30 being derived from the decennial report of the Registrar-General for that period[1] (Tables M and N).

1. Supplement to the Seventy-Eighth Annual Report.

TABLE XXVI.

Death-rates per million from cancer of various locations, by sex and age, Scotland, 1931–7

	All ages	–25	25–	35–	45–	55–	65–	75–	85 +
				Males					
All locations	1479	37	144	515	1691	4615	10197	14439	16272
Buccal cavity, etc.	140	2	5	13	107	472	1081	1462	2396
Digestive organs, etc.	929	10	73	300	1032	2984	6614	9057	8387
Respiratory organs	135	4	26	106	295	451	641	627	271
Breast	3	0	0	1	6	3	12	49	116
Male genito-urinary organs	150	5	16	33	112	377	1156	2009	2667
Skin	26	1	2	7	24	52	161	433	1353
Other or unspecified organs	96	15	23	54	116	278	533	801	1082
				Females					
All locations	1598	28	164	787	2152	4352	8394	12526	13733
All locations excluding breast and uterus	1161	26	105	415	1276	3066	6667	10325	11101
Buccal cavity, etc.	29	1	3	9	35	82	143	246	346
Digestive organs, etc.	857	6	59	255	818	2221	5227	8317	8070
Respiratory organs	63	3	11	40	119	197	294	241	191
Uterus	180	1	33	198	391	503	691	657	502
Other female genital organs	72	3	16	51	147	222	280	326	312
Breast	257	1	26	174	485	783	1036	1544	2130
Skin	20	0	1	4	9	25	86	333	970
Other or unspecified organs	121	13	14	56	149	319	638	865	1212



Death-rates per million from cancer, by sex and age, Scotland, 1931–7.

Diagram 11.

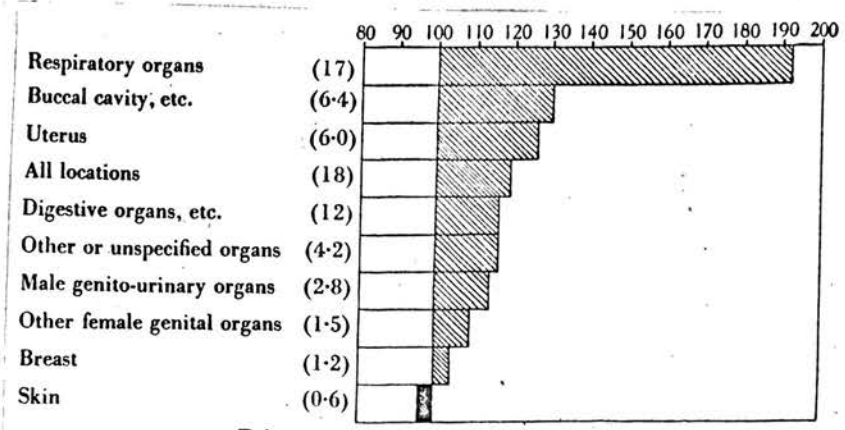


Diagram 12.

Standardized death-rates from cancer of various locations in urban as percentages of those in rural Scotland, 1931–7. "Urban Scotland" includes the four cities, Glasgow, Edinburgh, Dundee and Aberdeen; "Rural Scotland" includes the landward areas and small burghs. The figure given in brackets for each location is the ratio of the difference between the urban and rural rates to the standard error of the difference.

TABLE XXVII.

Crude and standardized death-rates per million from cancer of various locations, by geographical region, Scotland, 1931–7

		All Scotland	The four cities (urban Scotland)	The other twenty large burghs	Landward areas together with small burghs (rural Scotland)	The four cities: Glasgow	Edinburgh	Dundee	Aberdeen	The four divisions of rural Scotland: Northern	West-Central	East-Central	Southern
All locations	Crude rate	1541	1575	1482	1531	1470	1746	1753	1615	1762	1351	1377	1728
	Factor	1·0000	1·0679	1·0969	0·9222	1·1608	0·9373	0·9739	1·0115	0·7599	1·1010	1·0626	0·8204
	Standardized rate	1541	1682	1626	1412	1706	1637	1707	1634	1339	1487	1463	1418
	Standard error	±6·6	±12	±18	±9·2	±16	±22	±37	±37	±14	±18	±20	±27
Buccal cavity, etc.	Crude rate	82·1	85·1	81·1	79·9	76·2	101	102	84·8	98·2	59·2	77·0	92·9
	Factor	1·0000	1·1058	1·0862	0·9033	1·1728	0·9925	1·0643	1·0715	0·7372	1·0937	1·0379	0·8194
	Standardized rate	82·1	94·1	88·1	72·2	89·4	100	109	90·9	72·4	64·7	79·9	76·1
	Standard error	±1·5	±2·8	±4·2	±2·0	±3·7	±5·6	±9·7	±9·0	±3·2	±3·8	±4·6	±6·2
Digestive organs, etc.	Crude rate	892	885	880	901	835	963	1012	875	1050	794	798	1004
	Factor	1·0000	1·0781	1·1019	0·9149	1·1767	0·9412	0·9810	1·0160	0·7445	1·1061	1·0627	0·8129
	Standardized rate	892	954	970	824	983	906	993	889	782	878	848	816
	Standard error	±5·1	±8·8	±14	±6·9	±12	±16	±28	±27	±11	±14	±15	±20
Respiratory organs	Crude rate	97·3	129	87·9	73·3	141	122	100	102	62·1	91·9	68·1	64·2
	Factor	1·0000	1·0392	1·0518	0·9531	1·0815	0·9531	1·0160	1·0302	0·8407	1·0694	1·0369	0·8706
	Standardized rate	97·3	134	92·5	69·9	152	116	102	105	52·2	98·3	70·6	55·9
	Standard error	±1·7	±3·2	±4·2	±2·1	±4·6	±5·9	±9·2	±9·5	±2·9	±4·6	±4·3	±5·5
Uterus	Crude rate	93·2	104	87·3	86·4	91·2	108	125	150	90·4	78·1	84·6	103
	Factor	1·0000	1·0078	1·0911	0·9660	1·1098	0·8784	0·8930	0·9630	0·8395	1·0951	1·0885	0·8465
	Standardized rate	93·2	105	95·3	83·5	101	94·9	112	144	75·9	85·5	92·1	87·2
	Standard error	±1·6	±2·8	±4·4	±2·3	±3·8	±5·1	±9·0	±11	±3·5	±4·3	±5·0	±6·8
Other female genital organs	Crude rate	37·6	39·3	32·0	38·0	31·0	58·1	41·9	39·9	41·3	32·2	36·6	50·5
	Factor	1·0000	1·0139	1·0958	0·9581	1·1193	0·8777	0·8798	0·9708	0·8206	1·0991	1·0925	0·8433
	Standardized rate	37·6	39·8	35·1	36·4	34·7	51·0	36·9	38·7	33·9	35·4	40·0	42·6
	Standard error	±1·0	±1·7	±2·7	±1·5	±2·2	±3·7	±5·1	±5·6	±2·3	±2·8	±3·3	±4·7
Breast	Crude rate	134	134	117	141	117	160	148	156	169	117	120	175
	Factor	1·0000	1·0275	1·1094	0·9458	1·1484	0·8755	0·8934	0·9596	0·7899	1·1141	1·0973	0·8284
	Standardized rate	134	138	130	133	134	140	132	150	133	130	132	145
	Standard error	±2·0	±3·3	±5·2	±2·8	±4·4	±6·2	±9·8	±11	±4·5	±5·4	±6·1	±8·7
Male genito-urinary organs	Crude rate	72·2	68·5	68·4	76·7	63·5	80·3	77·4	59·8	86·8	62·0	75·9	91·6
	Factor	1·0000	1·1317	1·0807	0·8878	1·1837	1·0388	1·1208	1·0875	0·7175	1·0875	1·0235	0·8056
	Standardized rate	72·2	77·5	73·9	68·1	75·2	83·4	86·7	65·0	62·3	67·4	77·7	73·8
	Standard error	±1·4	±2·6	±3·8	±2·0	±3·4	±5·2	±8·9	±7·7	±2·9	±3·8	±4·5	±6·1
Skin	Crude rate	22·8	19·4	20·2	26·6	17·2	23·8	25·0	16·6	32·0	22·3	20·6	36·8
	Factor	1·0000	1·1406	1·1466	0·8690	1·2807	0·9605	1·0379	1·0478	0·6499	1·1117	1·0896	0·8172
	Standardized rate	22·8	22·1	23·2	23·1	22·0	22·9	25·9	17·4	20·8	24·8	22·4	30·1
	Standard error	±0·8	±1·4	±2·2	±1·1	±1·9	±2·6	±4·7	±3·9	±1·6	±2·4	±2·5	±3·9
Other or unspecified organs	Crude rate	109	111	108	109	97·5	130	123	130	132	94·8	96·3	109
	Factor	1·0000	1·0555	1·0878	0·9301	1·1439	0·9367	0·9691	1·0124	0·7768	1·0890	1·0608	0·8346
	Standardized rate	109	117	117	101	112	122	119	132	103	103	102	91·0
	Standard error	±1·8	±3·0	±4·8	±2·4	±4·1	±6·0	±9·7	±10·6	±3·9	±4·7	±5·2	±6·9

The standard errors are those of the standardized rates.

TABLE XXVIII.

Death-rates from cancer of various locations, by sex and age, in Scotland, 1931–7, as percentages of those in Scotland, 1921–30

	All ages	–25	25–	35–	45–	55–	65–	75–	85+
				Males					
All locations	118	123	104	105	101	98	108	117	130
Buccal cavity, etc.	95	100	100	41	51	78	99	98	102
Digestive organs, etc.	115	125	94	96	95	96	106	117	129
Respiratory organs	185	133	173	189	230	147	149	172	114
Male genito-urinary organs	142	100	145	122	138	114	121	132	199
Skin	104	100	50	100	104	118	89	82	108
Other or unspecified organs	110	125	96	102	84	99	103	110	130
				Females					
All locations	109	108	86	93	92	92	102	110	116
Buccal cavity, etc.	97	100	75	64	69	91	92	97	80
Digestive organs, etc.	109	100	92	94	88	88	99	113	126
Respiratory organs	147	150	138	125	125	126	156	120	303
Uterus	93	100	61	84	84	78	97	100	116
Other female genital organs	144	100	123	124	132	141	129	134	130
Breast	114	—	118	96	97	103	109	116	97
Skin	95	—	50	100	56	81	85	85	107
Other or unspecified organs	98	100	61	89	90	85	96	87	103

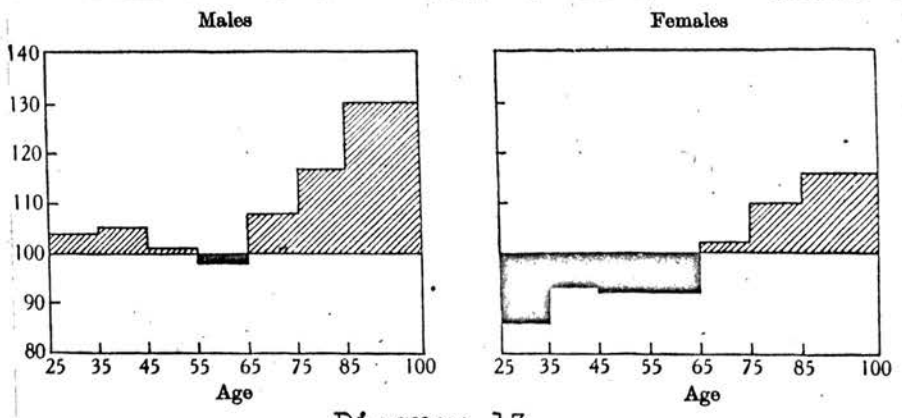


Diagram 13.

Death-rates from cancer, by sex and age, in Scotland, 1931–7, as percentages of those in Scotland, 1921–30.

TABLE XXIX.

Equivalent average death-rates per million, at ages 25–65, from cancer of various locations, by sex, Scotland, 1921–30 and 1931–7

	1921–30	1931–7	Rates in 1931–7 as percentages of those in 1921–30	Difference / s.e. of diff.
	Males			
All locations	1747	1741	100	0·3
Buccal cavity, etc.	212	149	70	9·1
Digestive organs, etc.	1150	1097	95	2·9
Respiratory organs	126	220	175	13·6
Male genito-urinary organs	113	135	119	3·8
Skin	19·5	21·3	109	0·8
Other or unspecified organs	124	118	95	1·1
	Females			
All locations	2031	1864	92	8·0
Buccal cavity, etc.	39·8	32·3	81	2·6
Digestive organs, etc.	950	838	88	7·5
Respiratory organs	72·8	91·8	126	4·3
Uterus	351	281	80	8·4
Other female genital organs	80·5	109	135	6·1
Breast	367	367	100	0
Skin	13·3	9·8	74	2·1
Other or unspecified organs	157	135	86	3·8

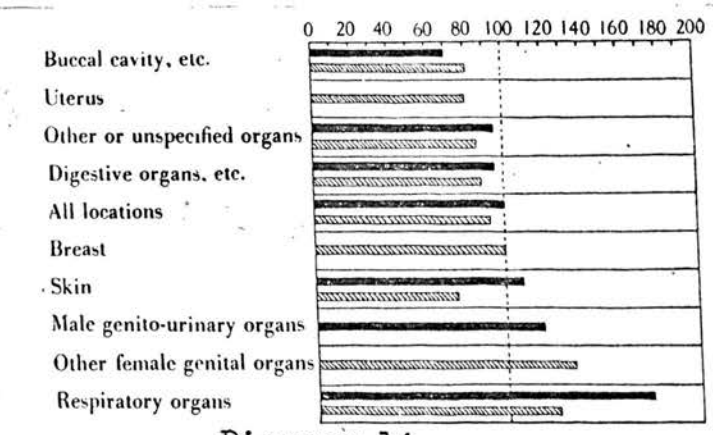


Diagram 14.

Equivalent average death-rates, at ages 25–65, from cancer of various locations in Scotland, 1931–7, as percentages of those in Scotland, 1921–30. The black columns refer to males, the shaded columns to females.

TABLE XXX.

Death-rates per million from cancer of various locations, for all ages and both sexes combined, Scotland, 1921–30 and 1931–7

	1921–30 (standardized on basis of 1934 population)	1931–7 (actual)	Rates in 1931–7 as percentages of those in 1921–30	Difference / s.e. of diff.
All locations	1521	1541	101·3	2·2
Buccal cavity, etc.	98·1	82·1	84	7·6
Digestive organs, etc.	893	892	100	0·1
Respiratory organs	62·5	97·3	156	16·6
Uterus	110	93·2	85	7·3
Other female genital organs	28·5	37·6	132	7·0
Breast	130	134	103	1·5
Male genito-urinary organs	58·1	72·2	124	7·8
Skin	25·5	22·8	89	2·5
Other or unspecified organs	116	109	94	2·9

3. DISCUSSION.

(a) General.

In the discussion of the distribution of cancer as revealed by the statistics published by the Registrar-General, it is to be remembered that such statistics are derived from the information recorded on death certificates. The cause of death is that set down by the certifying doctor, and, where two or more causes are entered, cancer, in general, is given precedence. When the certification is made, the whole course of the disease, including its fatal termination, is of course already known. The problem of early diagnosis is not here of importance, except, perhaps occasionally, in connection with assigning the location of the primary tumour.

Some of the features of cancer mortality are well known. As will be seen from Table XXVI and Diagram 11, for both males and females the rates are almost inappreciable below the age of 25, rising steeply after 55. At the younger ages the female rate exceeds the male, but after the age of 55 the reverse is true. In women cancer of the breast and uterus is a very important cause of death, and it happens that cancer is particularly liable to attack these two sites during the age period 35-65. Cancer of the uterus is a

danger peculiar to the female, and that of the breast almost so, and there is no corresponding hazard in the male. Though the prostate or testis is sometimes affected, the incidence of cancer in these organs is small compared with that of breast and uterine cancer in women. If the incidence in all sites other than breast and uterus in females be compared with the total rate in males, it is found that in all age-groups the female rate is substantially below that of the male, the excess in the latter being of the order of 40%. It is well known that the male organism is, in general, subject to higher death-rates than the female, a peculiarity shown in respect of most diseases and at all ages (Crew, 1937). It is, perhaps, reasonable to look upon the male excess in cancer of locations other than breast and uterus as a further expression of this greater instability of the male organism.

Before discussing the various locations separately, reference may be made to the English Registrar-General's Decennial Supplement, 1931, part of which deals with occupational mortality, and, inter alia, discusses the effect of social class on disease (pp. 19-75). Although some diseases, such as angina pectoris and cirrhosis of the liver, affect the well-to-do much more than the poor, most maladies behave in the opposite way, and work most havoc where economic

distress is most severe. For all diseases combined, the mortality among unskilled labourers (aged 20-65) is about 23% greater than that among the professional classes. Cancer follows the general rule. For males aged 20-65 the mortality (after standardisation to correct for differences between sex and age distribution) is 39% greater among unskilled labourers than among the professional classes; for females the excess is less, being only 10% for married women and approximately 20% for single women.

For brevity we shall speak of a normal social gradient when the death-rate increases in passing from the well-to-do to the poor, and of an inverse gradient when the reverse is the case. The English statistics bring out the fact that certain locations have very characteristic social gradients. The skin, buccal cavity, and alimentary tract down to the pylorus have a well-marked normal gradient. For organs of the digestive tract below the pylorus there is little or no gradient. Of the sex organs, the uterus has a normal, and the ovary, testis, and female breast, an inverse gradient. These facts are to be borne in mind in the discussion of our results in as far as they refer to the various locations.

The buccal cavity, the first location which we shall discuss, includes sites which are, for the most

part, highly accessible, so that we might expect the recorded figures to correspond closely to the actual facts. For this location we find the incidence in males much higher than in females, and also the incidence in towns substantially higher than that in the country. The greater incidence in males is in accordance with the general principle that, in the case of sites common to both male and female, the incidence in the male is usually higher. The higher rates in town as compared with country for this very accessible location would seem to argue an important influence of environment. There would seem to be little doubt that part of the urban cancer of this location is preventable in the sense that, if the same persons had been living in a rural environment, the incidence of mortality from cancer of the buccal cavity would have been considerably less.

A comparison of the death-rates at various ages for the periods 1921-30 and 1931-37 shows that, whereas in the age-groups over 65 the rates have remained substantially constant, in the younger age-groups the rates have actually become less. It is probable that this decrease is a real one, and no doubt is, in part, to be attributed to improvement in surgical and radiological treatment. However, it has to be borne in mind that a widespread improvement in conditions set

in during the latter part of the nineteenth century, resulting in a general decrease in the death-rates of the people who grew up in these improved surroundings, as compared with earlier generations (Kermack, McKendrick & McKinlay, 1934), and it is probable that the reduction in the death-rate from cancer of the buccal cavity is, in part at least, a result of the better environment. It is, perhaps, not too optimistic to hope that these generations will carry their lowered cancer death-rate along with them, as they have done their general death-rate, and that subsequent generations will progress to a still lower level of mortality.

A location which shows a number of similarities to the buccal cavity, in respect of the incidence of rumours, is the uterus. The difference between the urban and rural rates is of the same order - an urban excess of 30% for the buccal cavity and 26% for the uterus. The uterus resembles the buccal cavity in being, from the point of view of cancer diagnosis, a relatively accessible organ, and for this, as well as for other reasons, a location in which diagnosis is likely to be relatively accurate. In both locations, too, for the age-groups under 65, substantially lower rates have been recorded for the period 1931-37 as compared with those of 1921-30 (see Tables XXVIII,

XXIX, and Diagram 14). The change may be regarded as having occurred during an interval of 8½ years, that is, between 1925.5 and 1934, the mid-points of the two periods.

One other point of similarity between the locations has already been referred to. According to the report by the Registrar-General on occupational mortality, both these locations show a very marked normal social gradient. Of the five social classes into which the population of the country is divided, the lowest, Class V, shows, for both locations, about double that for the highest, Class I. For uterine cancer this statement applies to married women, but a similar gradient, though not so pronounced, is also observed for single women.

In sharp contrast to the buccal cavity and the uterus is the other important accessible site, the female breast. For this site there is no significant excess in urban as compared with rural areas. It has been clearly shown by the English Registrar-General that for this site there is a steep inverse social gradient, that is to say, the higher the social class the higher the incidence of recorded deaths. Cancer of this site also differs from that of the buccal cavity and the uterus in showing no improvement, even over the age-group 25-65, during the 8½ year interval

between 1921-30 and 1931-37. It is also in marked contrast to uterine cancer in being more common in single than in married women. It may be mentioned that, in the report dealing with the mortality from cancer in England and Wales for the period 1911-20, the only other comparable British investigation apart from that of Russell referred to above, a slight but definite and consistent urban excess of breast cancer was found, the magnitude of the excess being about 10%. Our own results, showing a 4% excess, are consistent both with the existence of an urban excess of 10%, and also with the assumption that there is no real urban excess. The relative uniformity may be related to the fact that cancer of the female breast is brought about by pre-eminently intrinsic causes, and so is much less dependent on environment than, say, that of the buccal cavity. Comparison of the specific age rates, or of the equivalent average death-rates, for the two periods, shows that not only has there been practically no change in cancer of the breast below the age of 65, but at higher ages there has even been a slight increase, the largest, one of 16%, being at ages 75-85. This failure of breast cancer to show any substantial decrease is perhaps surprising in view of the fact that surgical treatment of particular cases is often successful. The matter

is discussed by Dunlop (1930, p. 100), who found, up to 1928, an increase in breast cancer not explicable by the older age distribution of the population. Though, in an accessible site such as breast, the result of better diagnosis is likely to be small, it has been suggested that it may have the effect that a certain number of primary cancers of the breast, with secondaries elsewhere, will now be returned as cancers of that organ, whereas, in the past, they would have been referred to the secondary site.

About the other accessible location in the classification, namely skin, no definite conclusions can be drawn from the results, because of the smallness of the numbers. The figures are consistent with an absence of urban excess, but are also consistent with a real urban excess of, perhaps, 12%. It may be remarked that, on the basis of the England and Wales experience, the skin is to be classed with buccal cavity and uterus in showing a normal social gradient, and, in harmony with this, we find, on the whole, an improvement during the 8½ years, though, in consequence of the small numbers, the changes for particular age-groups show considerable variation.

The location digestive organs is the most important of all from the quantitative point of view. In Scotland, for example, it includes over 55% of all

deaths certified as due to cancer. Of this large group about 45%, i.e., about a quarter of all cancer deaths, are due to cancer of the stomach and oesophagus. Most of the organs classified under this location are to be regarded as inaccessible, in contrast to the buccal cavity, uterus, and breast. In spite of this inaccessibility, the urban excess for the digestive organs is only 16%, actually less than that for the buccal cavity and uterus.

There is some reason for believing that we may here be dealing with a location where better diagnosis may, in some measure, tend to reduce, rather than to increase, the number of certified deaths included within it. Where diagnosis is inexact, tumours having their primary site in such organs as the prostate, kidney, or breast, may be reported as cancers of the digestive tract. With more accurate certification these would be removed from this category and put in their proper locations. This tendency, of course, does not exclude the possibility of a fictitious urban excess due to the recording in the towns of cases of cancer of the digestive organs which would be ascribed to some quite different cause in the country. However, any urban excess, whether produced in this way or dependent on a real difference in incidence, would thereby tend to be diminished.

These observations are also to be borne in mind when considering the changes which have occurred during the 8½ years in the rates of incidence in this location. The equivalent average death-rate (25-65) shows a slight fall for each sex, whilst the standardised death-rate (Table XXX) remains unchanged. Inspection of the age specific death-rates shows that there has, in general, been a fall up to the age of 65. This accounts for the decline in the equivalent average death-rate; whilst at ages over 65 the age specific rates have increased. The standardised death-rate, of course, involves the rates over 65 as well as under 65. It seems likely that, in this inaccessible location, part, at least, of the fall under 65 is due to increased accuracy of diagnosis resulting in some transfer of certified deaths from this to other locations. At the same time it is possible that some of the improvement may be real.

As remarked above, about 45% of the cases are cancer of the stomach and oesophagus, sites which show a normal social gradient. Below the pylorus, however, there is, for the digestive organs, little or no social gradient - in marked contrast to the alimentary tract above the pylorus. Thus the whole location has a definite, though not very large, normal social gradient. Consequently, an improvement in

the general standard of life is likely to be accompanied by some decrease in the incidence of cancer in this location, quite apart from any reduction of the death-rate consequent on treatment. The figures presented, though consistent with this tendency, are not sufficiently definite to be considered as demonstrating it.

The greatest urban-rural differences are found in cancer of the respiratory tract, where the urban excess is in the neighbourhood of 90%. This location is also peculiar in showing an extraordinary increase in the number of recorded deaths during the 8½ years under review. The increase in the female equivalent average death-rate (between 25 and 65) is 26%, whilst the corresponding figure for males is 75%, that is to say, it is about three times as great for men as for women. It has been suggested that this may be dependent on the fact that employed men, being within the scope of the National Health Insurance Scheme, are more likely to report any incapacitating illness, and to be subjected to thorough efforts at diagnosis. If the patient is a worker under conditions rendering him liable to inhale fumes, dusts, etc., the question of possible compensation may ensure the medical examination being still more thorough. The fact that in the age-group 65-75 the rates of increase for

male and for female are substantially equal supports this view. In the age group 75-85 the recorded number of deaths is small, and, in consequence, the apparent excess in the male rate of increase is probably not significant. There would seem to be little doubt that the substantial increases in deaths from cancer of this location are, to a large extent, to be accounted for by more complete diagnosis, as new methods have been developed and brought into use.

It has been shown, in the report of the Registrar-General for England and Wales dealing with occupational mortality during the period 1930-2, that cancer of the larynx shows a very pronounced normal class gradient in males, but not in females. This suggests that cancer of this site is largely of occupational origin. On the other hand, cancer of the lung does not show a similar marked class differentiation in either sex, though in males and females the rate in Class V, which contains unskilled industrial labourers, is about 20% and 10% higher, respectively, than that of Class IV, which includes the bulk of agricultural labourers. This is in accordance with our finding, and, indeed, the large urban excess suggests that the difference between Classes IV and V may be a secondary one - that, in this instance, the distinction between urban and rural areas is the more fundamental. This is, of

course, consistent with the view that the difference in recorded death-rates may be dependent on diagnosis, as the newer methods might be expected to be more readily available to those within easy reach of the larger hospitals.

However, we hesitate to attribute the regional differences wholly to incomplete certification, because of the differences found amongst the larger towns. In particular, we note a standardised rate for Glasgow of 152 and for Edinburgh of 116. The difference is 36 and the standard error of this difference 7.5, so that it is probably significant.

The two locations, female genital organs other than the uterus, and the male genito-urinary tract, though not exactly comparable, may conveniently be considered together. Both groups of locations are somewhat heterogeneous, and include certain sites which may be considered accessible, and others which are relatively inaccessible. They do not, therefore, shed light on the primary object of the present investigation, the reality of the urban excess. Actually, the urban excesses for both these locations are nearly equal (9% and 14%, respectively), though it is very doubtful if the female excess is significant. During the period of 8½ years there was an increase in the reported cancer death-rates for both locations. It

is of interest to note that, for the ovary, there is an inverse social gradient, and that, for the prostate, the social trend, though less decided, is in the same direction.

Little need be said about the remaining location, which includes all sites not already classified, and so is very heterogeneous, except that the urban excess, though highly significant, is less than that found for the accessible locations buccal cavity and uterus. This is in spite of the fact that the miscellaneous sites which go to make up this location are, for the most part, relatively inaccessible. It may be noted that, in the interval between 1921-30 and 1931-37, a fall occurred in both sexes in cancer of this location (Tables XXVIII-XXX).

(b) Comparison with Russell's findings.

As mentioned above, our results, though in general agreement with those found for England and Wales by the Registrar-General for the years 1911-20, appear to diverge from those of Russell for Scotland for the period 1923-28. It is to be observed, however, that the findings of Russell, in as far as they bear on the present problem, are of a negative character. Thus, in the case of the buccal cavity, he states that in only one county (Midlothian) out of thirty-three is

the observed number of cancer deaths significantly greater than the calculated number (though the figures given in the paper indicate that, in both East Lothian and Forfar, the excess of actual over expected deaths is probably significant). As he treats each county separately, he is working with relatively small units, in some of which the expected number of deaths for any one location is often very small, and so the sampling error is proportionately big. Under these conditions, the fact that the observed distribution of deaths is consistent with the assumption of uniformity does not show that there is, in reality, such uniformity, and that there is no urban excess.

The figures given by Russell were further analysed as follows. An index of industrialisation was found for each of the thirty-three counties (including the Large Burghs in each county). This was calculated from the Report on the Census for 1931, which lists twenty-two different Industry Orders, giving the numbers engaged in each in the various counties. The first two of these industries, which we shall call Group A, are predominantly non-urban, namely, I, Fishing, and II, Agriculture. The next twelve on the list (Group B) cover most of the typical industrial occupations:

III. Mining and Quarrying.
IV. Manufacture of Bricks, Pottery, Glass, etc.
V. Manufacture of Chemicals, etc.
VI. Manufacture of Metals, Machines, etc.
VII. Textile Industry.
VIII. Manufacture of Leather and Leather Goods.
IX. Clothing Manufacture.
X. Manufacture of Food, Drink, and Tobacco.
XI. Wood Working.
XII. Paper and Stationery Manufacture: Printing.
XIII. Building and Contracting: Decorating.
XIV. Other Manufacturing Industries.

The remaining eight industries refer to activities common to both urban and rural areas:

XV. Gas, Water, Electricity.
XVI. Transport and Communication.
XVII. Commerce and Finance.
XVIII. Public Administration and Defence.
XIX. Professions.
XX. Entertainments and Sport.
XXI. Personal Service.
XXII. Other Industries or Industry not stated.

To some extent this division is an arbitrary one, but is convenient and suitable for practical purposes. The "index of industrialisation" chosen is the ratio of those employed in Group B to those in Group A. Table XXXI shows the counties in ascending order of industrialisation.

TABLE XXXI.

Degree of industrialization of Scottish counties

County (including large burghs)	Index of industrialization	County (including large burghs)	Index of industrialization
Orkney	0·2	Aberdeen	1·4
Sutherland	0·3	East Lothian	1·4
Wigtown	0·4	Roxburgh	1·9
Banff	0·5	Peebles	2·4
Berwick	0·5	All Scotland	4·95
Caithness	0·5		
Kincardine	0·5	Ayr	5·8
Kirkcudbright	0·5	Fife	6·8
Nairn	0·5	Selkirk	7·0
Ross and Cromarty	0·5	Forfar	7·5
Argyll	0·7	Stirling	10·1
Inverness	0·7	West Lothian	10·1
Moray	0·7	Midlothian	13·0
Zetland	0·7	Dumbarton	17·7
Bute	1·0	Clackmannan	18·2
Perth	1·2	Renfrew	24·3
Dumfries	1·3	Lanark	32·1
Kinross	1·3		

By choosing some suitable point of division we may separate the counties into the more and less highly industrialised, and compare the expected with the actual number of cancer deaths in each division. We choose, somewhat arbitrarily, as dividing point, the index 4.95, which corresponds to the mean degree of industrialisation of the whole of Scotland (the result is substantially the same whatever the dividing point chosen, over a wide range), and obtain Table XXXII.

Table XXXII.

	Breast		Buccal cavity	
	Actual	Expected	Actual	Expected
Counties with index of industrialization less than 4·95	1009	1086	622	697
Counties with index of industrialization greater than 4·95	2442	2360	1529	1462

Investigation of the goodness of fit by the usual formula gives P = 0.0038 and 0.0010 for breast and buccal cavity respectively. According to this result, there is an excess, very probably significant, of breast cancer in the more industrialised counties, and a very definite excess of buccal cavity cancer. The latter result is what we have found for the later period. The breast cancer finding is consistent with the England and Wales experiences for the years 1911-20, and cannot be regarded as inconsistent with our own result, since the absence of significant deviation from uniform distribution does not exclude the possibility of, say, a 10% difference between urban and rural areas. The urban excess, however, would seem to be less in the breast than in the buccal cavity mortality.

(c) Recent changes in Scottish cancer mortality.

A fact of some significance is that during the interval between 1921-30 and 1931-7 improvement has been most pronounced at the younger ages. For all deaths from cancer, at ages 25-65, there was, in the case of women, a net improvement of 8%, whilst, in the case of men, the incidence remained almost exactly constant. At the same time, for ages 65-85, there was a considerable deterioration, an increase of 13% being found for men, and 6% for women. This may

suggest that modern therapeutic methods are postponing death rather than curing the disease. Even though this were true, the postponement of many deaths from middle to old age would be a satisfactory achievement. It is doubtful, however, whether the statistical facts are wholly to be explained in this way. The people over 65 years of age in 1931-37 are not, in general, the same individuals as those under 65 years of age in 1921-30. The people, for example, who were 85 and over in 1931-37 must have emerged from the under 65 group before 1917. Up to this time little improvement had taken place, even in those under 65. To obtain a clear picture of the course of events, it would be necessary to study generation mortalities, that is, to follow the course of a particular generation throughout life, and thus to ascertain whether, for such a generation, a low mortality in middle age resulted in a higher mortality later on. The data at present available do not permit of this being done. It is to be remembered, however, that, in the case of the death-rate from all causes, the fall, apart from infant deaths, began in the younger age-groups, and that the improvement was carried by the generation throughout life (Kermack, McKendrick & McKinlay). It may be considered optimistic to expect that a similar course will be exhibited in cancer mortality, and

that the present fall in cancer deaths at younger ages will be followed, in a few decades, by corresponding falls at higher ages. The figures, however, are just as consistent with this interpretation as with the hypothesis of delayed deaths.

It might be anticipated that, where there is a normal social gradient, there will be a progressive improvement in death-rates, corresponding to the general rise in the standard of living. Where, on the contrary, the social gradient is inverse, an increase in mortality is to be expected, or, if other advantageous factors are having an effect, a decrease less marked than in the case of the locations with normal social gradients. How far this anticipation is realized is reflected in Table XXXIII.

Table XXXIII.

	Equivalent average death-rates (25–65) in Scotland, 1931–7, as percentages of those in 1921–30 (cf. Table IV and Fig. 4)		Standardized death-rates (35–65) in Social Class V as percentages of those in Social Class I, England and Wales, 1930–2	
	Males	Females	Males	Married women
Buccal cavity	70	81	195	—
Uterus	—	80	—	200
Other female genital organs	—	135	—	60
Digestive organs	95	88	140	155
Breast	—	100	—	60
Male genito-urinary organs	119	—	100	—
Skin	109	74	225	—
Respiratory organs	175	126	110	100

For some locations the figures in the last two columns are only approximate, being obtained by weighting the values for the constituent sites.

It will be seen that there has been improvement only where there is a normal social gradient, but that

the reverse does not always hold, as, for example, in the case of the respiratory tract. As mentioned above, there has been a very rapid increase in the number of certified deaths from cancer of this location. At the same time it shows but little social gradient, though what there is is normal in type. It has already been remarked, however, that much of the increase of cancer of the respiratory tract is unquestionably due to improvement in diagnosis, so that undue importance should not be attached to this location.

(d) Reality of urban excess.

In interpreting these results, the known facts relating to the effects of industrial and social conditions on cancer must be borne in mind. The special liability of workers in particular occupations to develop cancers of the skin, etc., in consequence of subjection to carcinogenic agents, is now general knowledge. The greater liability of the poor to develop cancer of the buccal cavity and stomach, and of the skin and uterus, and their relative immunity from cancers of the breast, ovary, and testis, and, to a lesser extent, of the prostate, has been strikingly demonstrated in the two reports on occupational mortality by the Registrar-General for England and Wales for the years 1921-23 and 1930-32. The results

seem too consistent and specific to be attributed mainly to variations in certification. Certain ways of life, perhaps certain types of diet, appear to promote or retard the development of cancers in particular sites. Such differences in habits of food, and in hygiene, in environment in the broad sense, undoubtedly exist as between town and country, and the observed differences would seem, in part, to be due to this. There is little doubt that some of the apparent urban excess is due to defective certification in rural areas, but the weight of the evidence is against the view that this is the whole explanation. An urban or industrial "milieu" would appear to be conducive to the development of cancers, and the identification of the particular elements of such an environment which are responsible, and their ultimate removal, would be an obvious means of reducing future cancer mortality.

CHAPTER V.

FERTILITY IN SCOTLAND: A COMPARISON OF URBAN AND RURAL AREAS.

Although, as is well known, a general fall in the birth-rate has occurred during the past seventy years, there seems to be little information on the question as to how the fall proceeded in various parts of the country. One might have ventured to guess that it began in the more sophisticated centres of population, such as the big towns, and afterwards spread to the rural parts of the country. Clearly, definite information on this point might be of some assistance in forming an opinion as to the causes which have been at work to bring about the general decline.

It was therefore decided to attempt to analyse the changes in the birth-rate with respect to its relation to urban and rural environment. We shall first of all consider the crude birth-rate from this point of view. We shall next deal with the general fertility rates. These make allowance for the proportion of women of child-bearing age in the community, but do not take into consideration the actual age distribution of these women. To correct for differences in such age distributions is scarcely possible for the whole period covered by this study, as, in the

earlier years, the required data are not always available. However, in the third section of this chapter a special analysis has been made of the period 1926-35, in which the general legitimate fertility rates have been standardised, and the figures have been worked out for each county separately. This detailed study over a particular decade to some extent supplements the vaguer results of the first two sections.

1. CRUDE BIRTH-RATES.

Crude birth-rates for the town and country districts of Scotland during the past eighty years are presented in Table XXXIV and Diagram 15. The figures in the table are taken from exactly the same sources, and are for the same calendar periods, as those for the crude death-rates given in Table X (p. 55). The same process of averaging has been employed for the two tables.

The decline in the birth-rate was first apparent in the triennial period centred at 1881, and it evidently set in about the same time in the five different types of districts. Up to 1911 the rates for Small Towns were uniformly lower than those for Principal Towns and Large Towns, and the country rates were substantially lower than the Small Town Rates. The Insular-Rural rates were lowest of all.

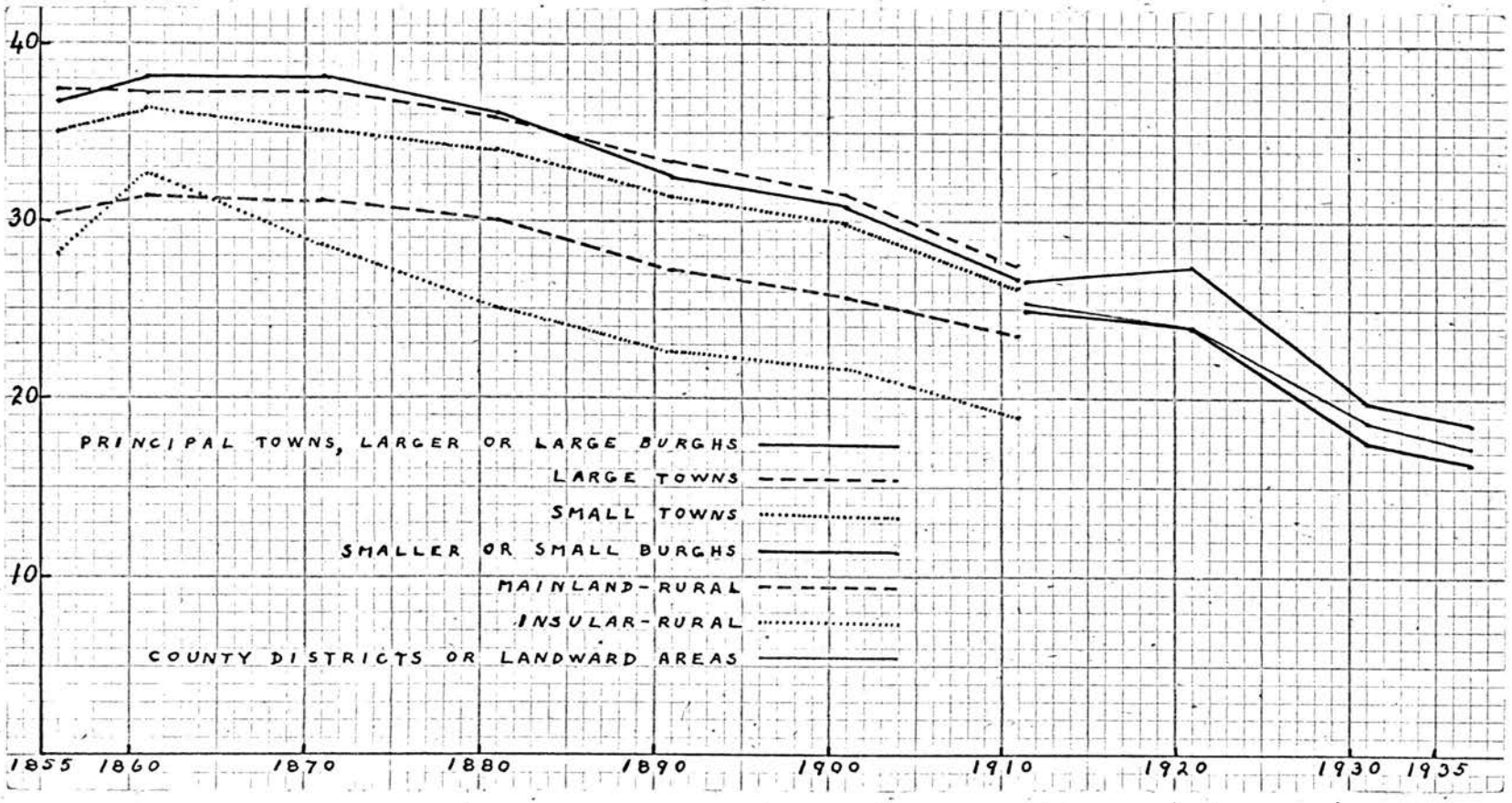


Diagram 15. Crude Birth-Rates in the Urban and Rural Divisions of Scotland, 1855-57 to 1936-38.

TABLE XXXIV.

Crude Birth-Rates in the Urban and Rural Divisions of Scotland, 1855-57 to 1936-38.

	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	SCOTLAND
1855-57	36.8	37.4	35.0	30.3	28.1	33.3
1860-62	38.1	37.2	36.4	31.4	32.6	35.0
1870-72	38.1	37.3	35.1	31.1	28.7	34.7
1880-82	36.1	35.9	34.0	30.0	25.0	33.5
1890-92	32.5	33.4	31.4	27.2	22.6	30.8
1900-02	30.8	31.5	29.9	25.7	21.7	29.4
1910-12	26.7	27.5	26.2	23.5	18.9	25.9
	Larger Burghs	Smaller Burghs	County Districts			
1911-12[a]	26.6	24.8	25.3			25.8
1920-22	27.4	23.9	23.9			25.6
	Large Burghs	Small Burghs	Landward Areas			
1930-32[b]	19.8	17.5	18.7			19.0
1936-38	18.5	16.3	17.2			17.7

Rates referring to years earlier than 1871, for the five divisions of the country created in that year, were published in the Seventeenth Detailed Annual Report (Abstracts of 1871).

a. Two-year period.

b. The rates for the period 1930-32 are the averages of the 1930 figures for Larger Burghs, Smaller Burghs and County Districts, and of the 1931 and 1932 figures for Large Burghs, Small Burghs and Landward Areas.

After the break in continuity in 1911, due to the changes in classification previously referred to, a somewhat different order is apparent. A rise occurred in the 1911 period from 23.5 for Mainland-Rural to 25.3 for County Districts in the same period, and a corresponding fall from 27.5 for Large Towns to 24.8 for Smaller Burghs. From that date to the present time, although the country continued to have a rate appreciably lower than that of the Larger Burghs, it was generally higher than that of the Smaller Burghs. During the entire period of eighty years, the rate for Principal Towns (or Larger Burghs) has maintained a higher level than the country rate.

The inversion, in 1911, of the relative levels of the birth-rates in the country and the smaller urban groups, as a result of the change in classification, is somewhat remarkable. An explanation of this unexpected feature of urban and rural birth-rates is not readily forthcoming. It rather looks as if the County Districts (or Landward Areas) contain some of the most fertile of the Small or even Large Towns. We know that various towns which have grown rapidly in recent years, but which have never acquired burghal status (such as Cambuslang and Carluke, both of which increased approximately threefold between 1911 and 1931), are included in the County Districts. The

transference of such units from the Large or Small Towns to the County Districts might account for the low birth-rate of the Smaller Burghs (which, by hypothesis, are frequently old towns which have not increased in size, or have even shown a decrease), and the relatively high fertility of the County Districts.

The sudden fall in the birth-rate which took place during the First World War, and the rise which followed, are not revealed in the diagram, owing to the system of presenting the figures for short periods centred, for the most part, at Census years. These abnormal changes are clearly discernible in Diagrams 16 to 21, in the next section.

From the point of view of our general enquiry, the chief features shown by Diagram 15 are the almost simultaneous commencement of the fall in the birth-rate in all five geographical divisions, and the general parallelism which is manifest in the course of the curves, in spite of the complications resulting from the changes in classification.

2. GENERAL FERTILITY RATES.

(a) Data and Details of the Construction of the Tables.

The crude birth-rate in any section of the community is largely determined by the proportion of women at the reproductive age. For this reason we shall now consider those measures of fertility which take this proportion into account, namely, the general fertility rates (see p. 42). A series of six tables has therefore been constructed, containing general fertility rates in various towns and divisions of Scotland during the past eighty years. Corresponding diagrams have been prepared and are placed facing the tables which they illustrate. A brief account of how the tables were made will now be given.

General total, general legitimate, and general illegitimate fertility rates were calculated for the different urban and rural districts for each Census year from 1861 to 1901, by relating the total, legitimate, and illegitimate births, taken from the Registrar-General's Annual Reports, to the total, married, and single women respectively, aged 15-45, taken from Census Reports and the Annual Reports for certain years (Tables XXXV, XXXVI, and XXXIX).

For 1861 the average was taken of the births in 1860, 1861, and 1862. Although neither vital nor Census statistics were published in those years for

the Principal Town Group and the Large Town Group (which were not defined officially until 1871), it was possible to obtain rates for the former Group by taking the sum of the births, and of the relevant women aged 15-45, in the individual towns forming the Group. The difference between the figures for Principal Towns, thus found, and the figures for "Town", 1861, resulted in figures and rates for the Large Town Group. The Mainland-Rural and Insular Groups of 1861 could not, unfortunately, be divided into their Small Town and rural components.

For 1871 it was impracticable to take the average over three years owing to certain differences in classification between 1870 and 1871.

In 1881, Kilmarnock, whose population had exceeded 25,000, was promoted from the Large Town to the Principal Town Group, and certain towns, for instance, Peterhead and Falkirk, were transferred from the Small Town to the Large Town category. At the same time, a number of townships, such as Lasswade and Prestonpans, whose populations had passed the 2,000 mark, became classified as Small Towns. These changes made it necessary to use the statistics of one year only, so that the Census data and those of the Registrar-General should be comparable.

Again, in 1891, for similar reasons, rates had to be calculated based on the births of a single year.

For this particular year, some difficulty was experienced in getting the distribution of women with respect to age and marital condition in the five different town and country divisions, for this distribution is not tabulated in the 1891 Census Report. However, it happens that, ten years later, two tables were published in the Forty-Seventh Annual Report (for 1901) giving the numbers of the population by age and sex, but not by marital condition, for the five districts in 1891 and 1901. The number of women aged 15-45, in the table for 1891, after slight adjustment to allow for discrepancies between the actual populations of the groups in 1891 and those given in the table, were used to calculate the general total fertility rates for 1891. An estimate of the number of single women in the age range 15-45 for the five districts was given in the Annual Report for 1891, and the difference between these estimates, corrected for certain errors, and the figures for all women aged 15-45, resulted in estimates of the numbers of married women aged 15-45. In this way approximate values of the general legitimate fertility rate and the general illegitimate fertility rate were obtained for the various urban and rural divisions in 1891.

Similar difficulties were encountered when attempting to calculate town and country fertility

rates for 1901. Again the required population data are lacking in the Census Report. The total women aged 15-45 in each type of district were abstracted from the table in the Annual Report for 1901, referred to above. A special investigation showed that, in the case of the Principal Towns, Large Towns, Small Towns, and Mainland-Rural, each taken separately, the proportion of married to total women in the age range 15-45 had remained approximately constant at the three previous Census years. In the case of the Insular-Rural Group, the proportion had steadily fallen, but as this Group was very small in number, the lack of estimates for it in 1901 is not a serious omission. By assuming, then, that the proportion of married women to total women in these four divisions was the same in 1901 as the average of the corresponding proportions for the three preceding Census years, estimates of the required numbers of married women were arrived at. The numbers of single women aged 15-45 were, of course, obtained by taking the difference between the married women and total women. The resulting general legitimate and illegitimate fertility rates for 1901, consequently, must be regarded as approximations. However, these are unlikely to be seriously in error, and, in the absence of official figures, it seems justifiable to include them

in our analysis. The Insular-Rural Group in this year is represented by a figure for the general total fertility rate only.

In 1902 the Registrar-General began to publish general total fertility rates for the urban and rural districts, followed, in 1912, by general legitimate and general illegitimate rates in addition. Average values of these annual rates over calendar periods of different lengths are included in the tables. The length of the periods during and after the First World War have been selected so as best to indicate the changes in fertility caused by that upheaval.

General legitimate fertility rates (Table XXXVII) and general illegitimate fertility rates (Table XL), for each of the four chief cities, have been obtained for the same calendar periods as the corresponding rates for the urban and rural districts. Those for the Census years 1861 to 1901 were computed from the basic data, namely, the numbers of legitimate and illegitimate births, and the numbers of the married and single women respectively, aged 15-45, in each city. When abstracting these data, difficulty occasionally arose as a result of the boundary of a town, for the purpose of the Registrar-General's returns of births, deaths, and marriages, being different from the boundary

adopted in the Census reports. The consequent differences in population are sometimes not inconsiderable. For example, in 1881, the population of the "Principal Town" of Dundee in the Registrar-General's Annual Report is 142,455, whilst the population of the "Parliamentary Burgh" of Dundee in the Census Report, to which we must refer for the distribution of women by age and marital condition, is 140,239. Small adjustments had thus to be made occasionally to ensure that the numbers of births were related to the appropriate numbers of females aged 15-45. Since 1902 the Registrar-General's Annual Reports have contained both general legitimate and general illegitimate fertility rates for individual Principal Towns (Larger Burghs since 1911), and these annual rates have been used to form average values for Glasgow, Edinburgh, Dundee, and Aberdeen, during various calendar periods as shown in the tables.

In Scotland we have two mountainous areas which have many points of similarity with each other, the Highlands and the Southern Uplands. In Chapter III we have already compared the course of the infantile mortality in a typical group of four Northern counties with that in a second group of four Border counties. The same two groups have been included in the study of fertility. General legitimate fertility rates

(Table XXXVIII) for these two groups have been computed for each Census year from 1861 to 1931. To reduce sampling errors the averages of the births have been taken over three-year periods. Rates for the War period 1917-19 and the post-War period 1923-25 are also included, using estimates, taken from the Registrar-General's Reports, of the numbers of married women aged 15-45 in each county. In the same way, figures for the triennial period 1937-39 have been calculated. In view of the unexpected trends of the figures set forth in Table XXXVIII, standard errors for the rates have also been worked out, and are included in the table. These were calculated from the approximate formula S.E. = $R/\sqrt{N}$, where R is the rate, and N the total number of births from which R was computed.

We may now proceed to examine the various tables and diagrams.

(b) General Total Fertility Rates.

Diagram 16 demonstrates the important fact that the decline of the general total fertility rate started about the same period in the five urban and rural divisions of the country.

Up to 1910 the rate for Large Towns was highest and, excepting the small Insular-Rural Group, that of Principal Towns lowest. The Mainland-Rural held an intermediate position throughout. In 1911 we have the same remarkable inversion of town and country levels observed in Diagram 15 in the case of the corresponding crude birth-rates. Up to 1910 the Mainland-Rural rate was appreciably below those of the Large Towns and Small Towns. In 1911, however, the rate for County Districts in the new classification was much higher than that of the new group of Smaller Burghs. These new levels have been maintained up to the present time. During the last two decades the Smaller Burghs Group has been definitely lowest, with the Larger Burghs in the intermediate position.

Throughout the period of eighty years the rate for Principal Towns (or Larger Burghs) has been constantly lower than the country rate, in contrast with the experience for the crude birth-rates.

Ignoring the small Insular-Rural Group, it is of some interest to observe that at the beginning of the

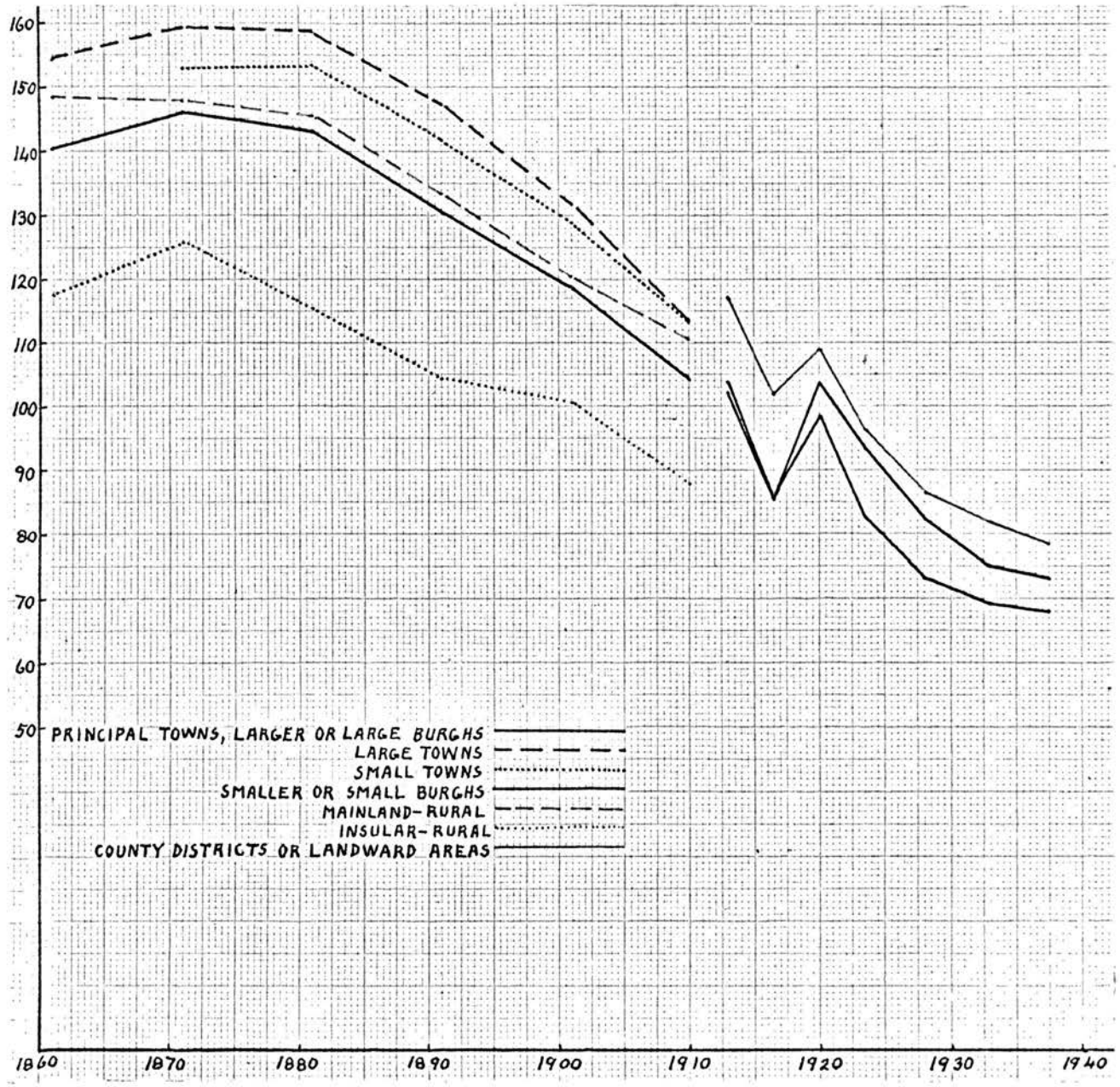


Diagram 16. General Total Fertility Rates in the Urban and Rural Divisions of Scotland, 1860-62 to 1936-39.

TABLE XXXV.

General Total Fertility Rates (Total Births per 1000 Women aged 15-45) in the Urban and Rural Divisions of Scotland, 1860-62 to 1936-39.

	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	SCOTLAND
1860-62	140.4	154.4	-	148.2 a	117.5 a	144.6
1871	146.0	159.4	152.8	147.7	125.7	148.6
1881	143.0	158.7	153.3	145.5	115.2	146.4
1891	130.4	147.4	141.6	133.3	104.4	134.4
1901	118.5	131.7	128.9	120.2	100.4	122.1
1910	104.2	113.6	113.2	110.2	87.9	108.0
	Larger Burghs	Smaller Burghs	County Districts			
1911	103.6	100.5	115.3			106.6
1912-14	103.9	102.0	116.9			107.3
1915-18	85.7	85.8	101.8			90.3
1919-21	103.5	98.2	108.8			103.9
1922-25	93.1	82.7	96.1			91.9
1926-30	82.4	73.1	86.1			81.7
	Large Burghs	Small Burghs	Landward Areas			
1931-35	75.0	69.0	81.8			76.0
1936-39	73.1	67.9	78.3			73.7

a. Includes Small Towns.

period under review, in 1860-62, the rates ranged from 154.4 for Large Towns to 140.4 for Principal Towns, a difference of 14.0. Seventy-five years later, in 1931-35, when the general level was about half of that originally prevailing, the rates ranged from 81.8 for Landward Areas to 69.0 for Small Burghs, a difference of 12.8. In spite of the very considerable fall, the degree of variation has remained extremely constant. The general parallelism of the lines (apart from the inversion of levels in 1911 already referred to) is obvious from the diagram. As far as these particular geographical divisions of Scotland are concerned, no significant differences in the course of the fall of general total fertility rates can be detected.

(c) General Legitimate Fertility Rates.

The general legitimate fertility rate, like the crude birth-rate and the general total fertility rate, began to fall in the various urban and rural areas almost simultaneously (Diagram 17). The same tendency for the rates, broadly speaking, to follow parallel courses in their descent is also noticeable. The curves are extremely regular from 1861 to 1901. During this period the figures for Large Towns, Small Towns, and Mainland-Rural are practically alike, whilst those for Principal Towns remain about 25 per 1000 lower throughout. The relative levels after 1911 are somewhat different, but there is not the same inversion that was experienced with the crude birth-rates and the total fertility rates. The outstanding feature of the last twenty years has been the consistently low level of the Smaller Burghs. During this time the County Districts (or Landward Areas) have been highest, with the Larger Burghs in the intermediate position. In fact, the picture for general legitimate fertility rates during the past two decades has been very similar to that for general total fertility rates.

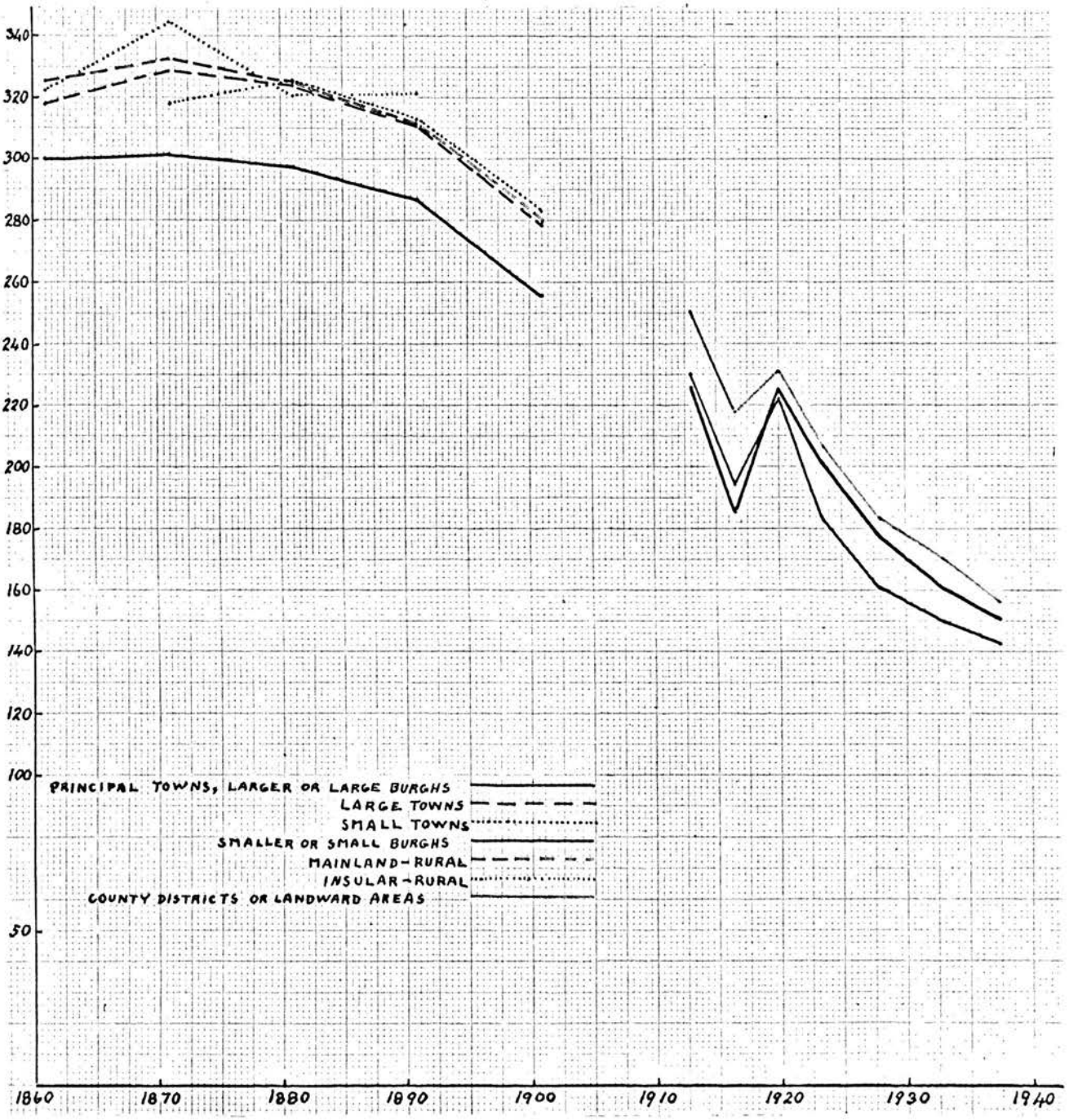


Diagram 17. General Legitimate Fertility Rates in the Urban and Rural Divisions of Scotland, 1860-62 to 1936-39.

TABLE XXXVI.

General Legitimate Fertility Rates (Legitimate Births per 1000 Married Women aged 15-45) in the Urban and Rural Divisions of Scotland, 1860-62 to 1936-39.

	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	SCOTLAND
1860-62	299.9	317.8	-	325.4 a	322.5 a	316.0
1871	301.1	328.3	317.7	332.3	344.3	317.4
1881	297.4	323.9	326.0	325.2	320.3	313.1
1891	286.8	310.4	312.8	311.0	321.2	300.4
1901	255.6	278.6	282.6	279.2	-	272.4
	Larger Burghs	Smaller Burghs	County Districts			
1912-14	225.8	230.0	250.1			233.9
1915-18	185.1	194.0	217.8			195.5
1919-21	225	222	231			226
1922-25	201.1	182.9	206.7			199.2
1926-30	177.3	160.2	183.4			175.8
	Large Burghs	Small Burghs	Landward Areas			
1931-35	160.4	149.8	170.0			161.5
1936-39	150.3	142.3	156.2			150.7

a. Includes Small Towns.

Diagram 18 illustrates the trends of the general legitimate fertility rates in Glasgow, Edinburgh, Dundee, and Aberdeen. The fall appears to have set in about two decades later in Aberdeen than in the other three cities. Since 1911 the curve for Glasgow has been consistently highest, whilst, throughout most of the period under review, the Edinburgh curve has been lowest. With these four chief cities, which might be expected to resemble each other more closely than obviously contrasting geographical divisions, such as we have dealt with in previous paragraphs, there is more evidence of each following its individual and characteristic course, and it is only within the last twenty years that the curves have tended to be approximately parallel.

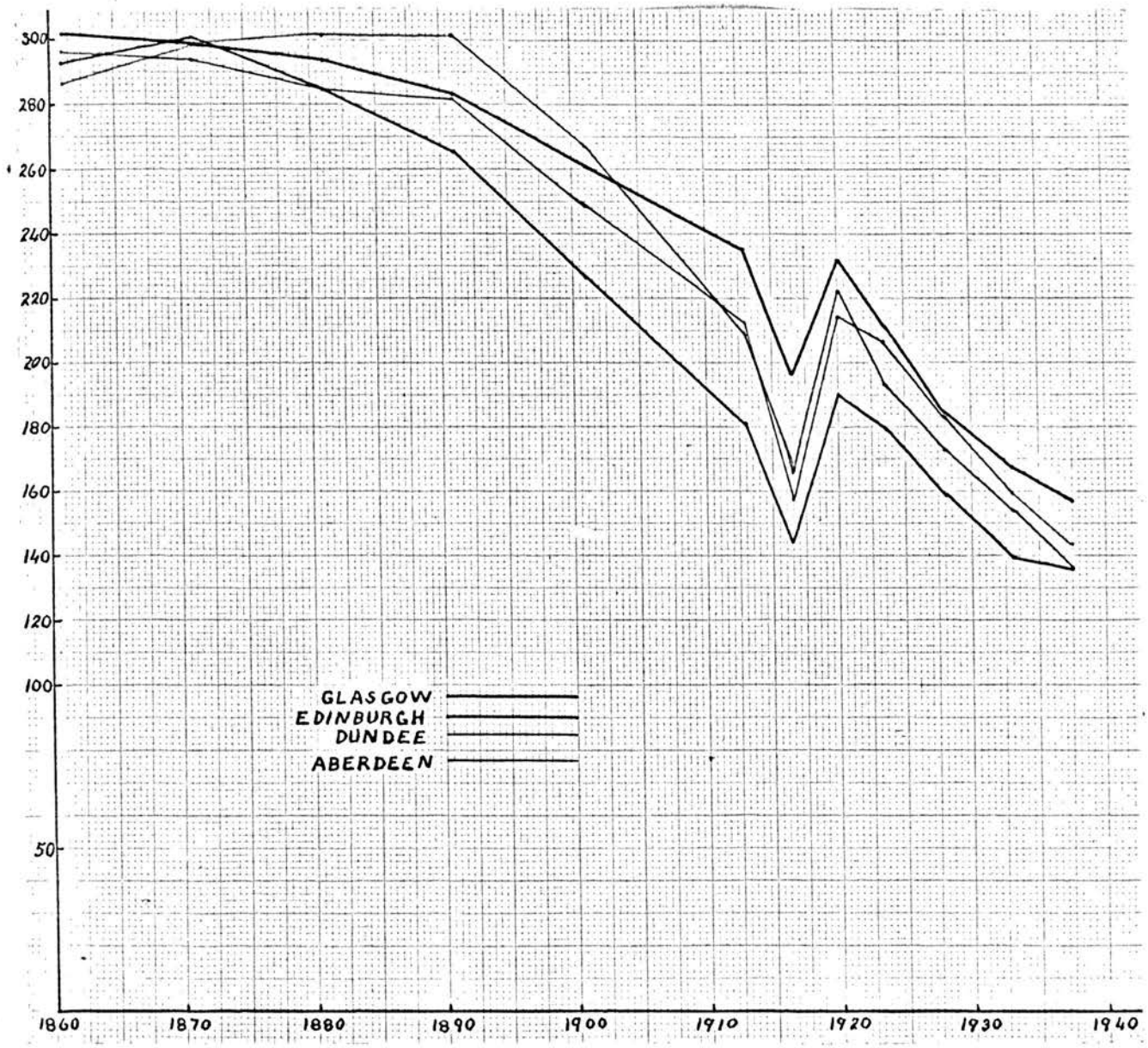


Diagram 18. General Legitimate Fertility Rates in the Four Chief Cities of Scotland, 1860-62 to 1936-39.

TABLE XXXVII.

General Legitimate Fertility Rates (Legitimate Births per 1000 Married Women aged 15-45) in the Four Chief Cities of Scotland, 1860-62 to 1936-39.

	Glasgow	Edinburgh	Dundee	Aberdeen
1860-62	301.7	292.5	296.0	286.3
1871	298.3	300.9	293.9	298.2
1881	293.4	284.4	284.2	301.6
1891	283.0	265.5	281.4	301.3
1901	260.4	226.4	248.7	266.9
1912-14	235.1	180.6	212.4	208.9
1915-18	196.2	144.8	157.5	165.9
1919-21	232	190	214	222
1922-25	211.5	179.3	206.9	193.0
1926-30	184.3	158.9	183.2	172.6
1931-35	167.1	139.4	159.4	154.0
1936-39	156.9	135.8	143.4	136.7

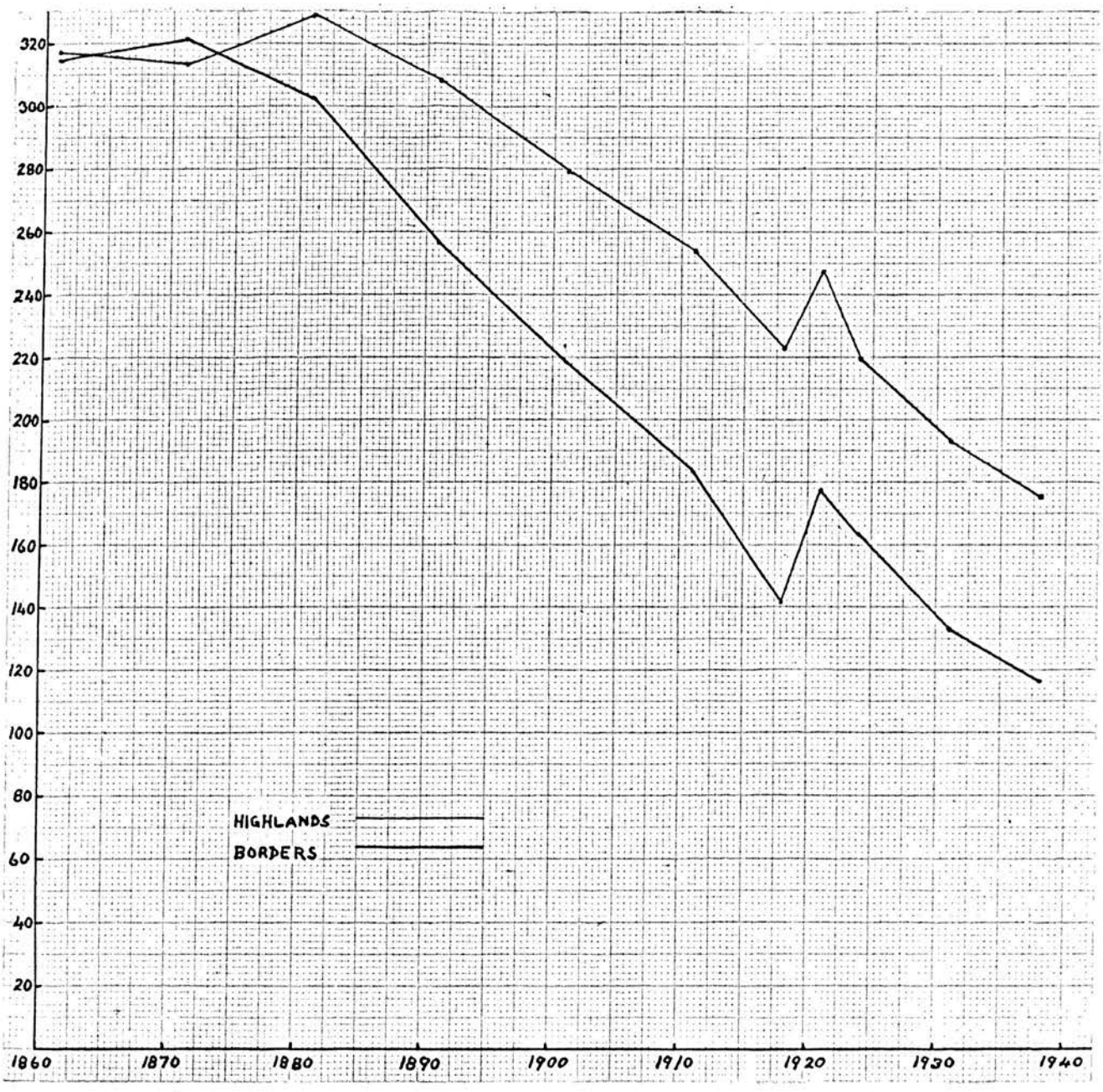


Diagram 19. General Legitimate Fertility Rates in the Highlands and Borders of Scotland, 1860-62 to 1937-39.

TABLE XXXVIII.

General Legitimate Fertility Rates (Legitimate Births per 1000 Married Women aged 15-45) in the Highlands and Borders of Scotland, 1860-62 to 1937-39.

	Counties of Sutherland Ross and Cromarty Inverness Nairn		Counties of Peebles Selkirk Roxburgh Berwick	
	Rate	S.E.	Rate	S.E.
1860-62	317.4	± 2.6	314.3	± 3.2
1870-72	313.4	± 2.6	321.7	± 3.2
1880-82	329.1	± 2.7	302.3	± 2.9
1890-92	308.2	± 2.7	256.1	± 2.8
1900-02	279.2	± 2.5	218.4	± 2.7
1910-12	253.9	± 2.5	183.2	± 2.4
1917-19 a	222.6	± 2.5	141.2	± 2.2
1920-22	247.2	± 2.5	177.8	± 2.3
1923-25 a	219.6	± 2.4	163.3	± 2.3
1930-32	192.8	± 2.3	132.9	± 2.0
1937-39 a	174.9	± 2.1	116.2	± 1.9

S.E. Standard error.

a. Rates are based on estimated numbers of married women aged 15-45.

In order to explain the reasons for selecting Sutherland, Ross and Cromarty, Inverness, and Nairn on the one hand, and Peebles, Selkirk, Roxburgh, and

Berwick on the other, for a special comparison of their legitimate fertilities, it is necessary to anticipate the results of section 3 of this chapter. The analysis of the standardised general legitimate fertility rates for the separate counties of Scotland for the period 1926-35, there described, will show that the former group of counties possessed remarkably high fertility, whilst that of the latter group was remarkably low. It was clearly of importance to ascertain whether this difference in fertility had always existed in the past, and, if not, at what time and in what manner it had developed.

From Diagram 19 it will be seen that both groups stood in 1861 at about the same level of 315 per 1000. In 1881 the Highland rate rose to 329.1 and the Border rate fell to 302.3, the difference being statistically significant. During the decline which followed in both groups the gap increased until, in 1911, the Border rate was 70.7 per 1000 lower than that of the Highlands, the standard error of the difference being only 3.5. Since then the rates for the two groups have followed more or less parallel courses in their descent. The difference in 1937-39 was 58.7, almost exactly 50 per cent. of the Border rate. In other words, the Highland rate was one and a half times the Border rate.

Here then we have two geographical regions which started at the same level of legitimate fertility, but which have now diverged to a very great extent. The Border group started falling first and by 1881 its fertility was well below that of the Highland group. In none of the other numerous comparisons which have been presented in this chapter has anything comparable to this contrast been encountered. If this difference had been between an urban and a rural community, it would not have been so unexpected, but, as we have already remarked, the general conditions prevalent in the two sets of counties have many points of similarity. It is true that the Border counties are, on the whole, more industrialized than the Highland ones. Thus, for example, the indices of industrialization of the separate counties are as follows (see p. 128): Sutherland, 0.3; Ross and Cromarty, 0.5; Inverness, 0.7; Nairn, 0.5; Peebles, 2.4; Selkirk,7.0; Roxburgh, 1.9; and Berwick, 0.5. The greater industrialization of the Border region is due very largely to the extent of the textile industry in certain of the Border towns. It was computed from data in the Report on the Fourteenth Decennial Census of Scotland (1931) that, taking the four Highland counties as a whole, 32.5 per cent. of those occupied were fishermen

or agricultural workers and less than one per cent. were textile workers. In the four Border counties, taken together, the corresponding percentages were 22.7 and 18.6 respectively. However, in view of the failure to detect any similar divergence between the levels of fertility in the highly industrialized great towns and the rural areas, it seems in no way probable that the fertility differences between Highlands and Borders can be attributed to the textile industry in the latter. Further, it will be shown in section 3 that Berwick, with its low index of industrialization 0.5, had, in 1926-35, in its Landward Area the lowest, and in its Small Burghs taken together the second lowest, standardised general legitimate fertility rate of any county in Scotland.

The elucidation of the cause of this contrast would seem to require a detailed knowledge of social conditions in the two areas, which at present is not readily available.

(d) General Illegitimate Fertility Rates.

The proportion of illegitimate births in Scotland has gradually fallen from 9 per cent. about 1875 to about 6 per cent. in 1938. Although the effect of this change on the decline of the birth-rate must have been inappreciable, we have, for the sake of completeness, included tables and diagrams showing the trends of the general illegitimate fertility rates in the urban and rural districts, and also in the four chief cities (Tables XXXIX and XL, Diagrams 20 and 21).

The prominent feature of Diagram 20 is the high illegitimate fertility rate in the country compared with those of the various town districts. This difference has been maintained from the days when our records begin to the present time. Although the rate has fallen substantially in every group, the country curve has never at any period tended to approach the town curves. The small Insular-Rural Group, it will be noticed, unlike the rest of the country, had an extremely low illegitimate fertility rate. Its value was only about 10 per 1000, that is, considerably less than half the rate for Mainland-Rural.

The general illegitimate fertility rate decreased sharply in every group during the First World War,

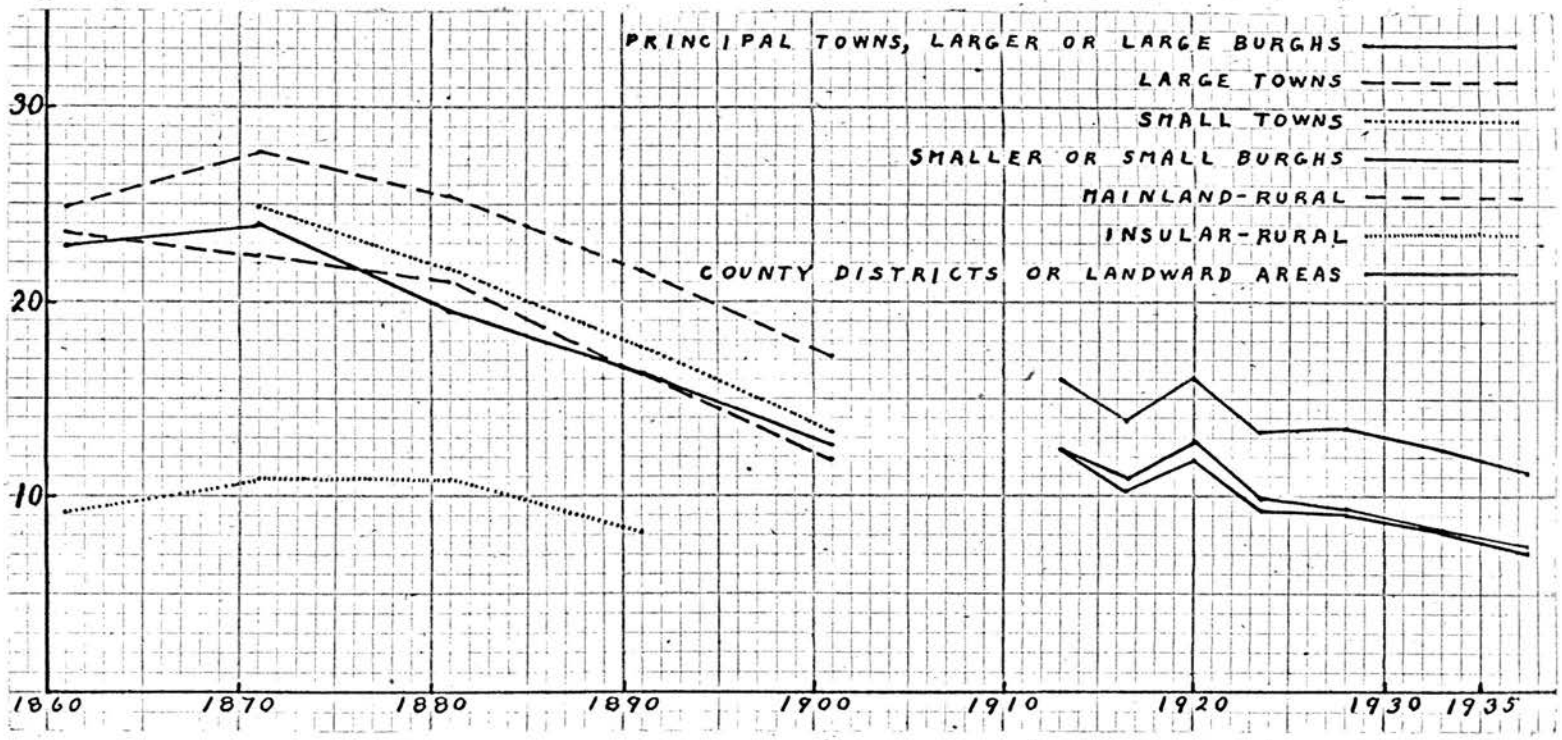


Diagram 20. General Illegitimate Fertility Rates in the Urban and Rural Divisions of Scotland, 1860-62 to 1936-39.

resembling in this respect the general legitimate fertility rate, and, like it, rose abnormally for a short period afterwards. During the Second World War the tendency was for both illegitimate and legitimate fertility rates to increase.

TABLE XXXIX.

General Illegitimate Fertility Rates (Illegitimate Births per 1000 Single Women aged 15-45) in the Urban and Rural Divisions of Scotland, 1860-62 to 1936-39.

	Principal Towns	Large Towns	Small Towns	Mainland-Rural	Insular-Rural	SCOTLAND
1860-62	22.9	23.6	-	24.9 a	9.2 a	23.2
1871	24.0	22.4	24.9	27.7	10.9	24.6
1881	19.5	21.0	21.7	25.4	10.9	21.3
1891	16.3	16.3	17.6	21.6	8.1	17.5
1901	12.7	11.9	13.2	17.1	-	13.3
	Larger Burghs	Smaller Burghs	County Districts			
1912-14	12.4	12.4	16.0			13.4
1915-18	10.9	10.2	13.8			11.5
1919-21	12.8	11.9	16.0			13.6
1922-25	9.9	9.2	13.3			10.8
1926-30	9.4	9.0	13.4			10.5
	Large Burghs	Small Burghs	Landward Areas			
1931-35	8.3	8.2	12.4			9.4
1936-39	7.5	7.1	11.1			8.5

a. Includes Small Towns.

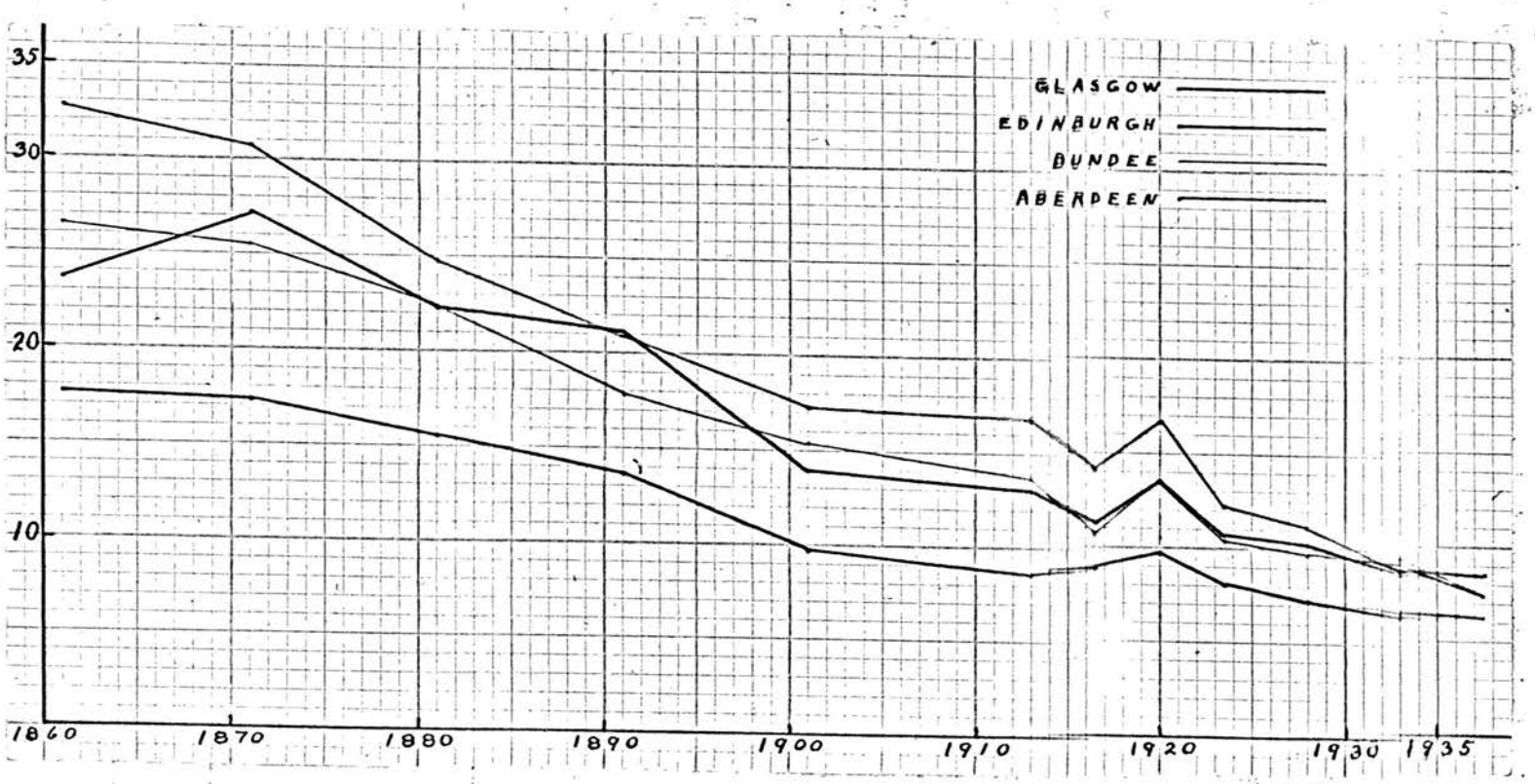


Diagram 21. General Illegitimate Fertility Rates in the Four Chief Cities of Scotland, 1860-62 to 1936-39.

TABLE XL.

General Illegitimate Fertility Rates (Illegitimate Births per 1000 Single Women aged 15-45) in the Four Chief Cities of Scotland, 1860-62 to 1936-39.

	Glasgow	Edinburgh	Dundee	Aberdeen
1860-62	23.6	17.7	26.5	32.8
1871	27.2	17.3	25.5	36.7
1881	22.2	15.5	22.2	24.8
1891	21.1	13.6	17.8	20.9
1901	13.9	9.6	15.3	17.2
1912-14	13.0	8.5	13.7	16.8
1915-18	11.3	8.8	10.6	14.1
1919-21	13.5	9.7	13.5	16.6
1922-25	10.6	8.0	10.4	12.2
1926-30	10.2	7.2	9.7	11.1
1931-35	8.7	6.5	9.4	8.8
1936-39	8.5	6.3	7.4	7.4

Of the four cities for which statistics are given (Diagram 21), Edinburgh is distinguished by having, at all times, the lowest illegitimate fertility rate. That of Aberdeen, until about 1930, was generally the highest. The curves for Glasgow and Dundee followed a middle path between those of Aberdeen and Edinburgh for many years. In recent times the figures for Glasgow, Dundee, and Aberdeen have tended to a common level, somewhat above that of Edinburgh.

3. STANDARDISED GENERAL LEGITIMATE FERTILITY RATES: A DETAILED SURVEY OF SCOTTISH COUNTIES AND BURGHS, 1926-35.

(a) Preliminary.

In section 2 (c) we have employed general legitimate fertility rates in our examination of the trends of fertility in urban and rural Scotland. Such rates, owing to the fact that the specific fertility rate differs markedly from age to age (as will be seen presently), suffer from the disadvantage that they do not make allowance for possible variations in the age distribution of married women within the reproductive age span. It is desirable to allow for this effect, and a process for standardising the general legitimate fertility rates is therefore called for. Some early calculations with this object in view were made by Newsholme and Stevenson in 1905 and 1906.

It was impracticable to standardise the rates for the entire period from 1861 onwards. The necessary specific fertility rates at different times in the past are not available, and the required Census data are also lacking for certain periods. The decade 1926-35 happens to be a suitable one in several respects for carrying out a more detailed enquiry, based on standardised rates, into the fertility experience

of different urban and rural areas. It is centred approximately at the Census year 1931, thus making it easy to get the essential Census data, and it gives a picture of fertility in Scotland midway between the First and Second World Wars, unaffected by the changes resulting from the former.

It was impossible to use the method of direct standardisation, for the data required in this process were not available for the numerous geographical divisions of Scotland which it was desired to survey. The adjustment has therefore been made by the indirect method of standardisation referred to on page 46. The actual arithmetical process is analogous to that employed in Chapter IV for correcting cancer death-rates in the different geographical regions of Scotland, and an example was set forth in detail in Table XXV (p. 103).

It happens that a review was carried out by Dr Enid Charles in 1938 of the total fertility (i.e., of married and single women combined) in the various counties and Large Burghs of Scotland. She adopted as the index of fertility the gross reproduction rate, which, it will be recalled, is a measure of the average number of female children born to a woman in passing through the child-bearing period, it being assumed that she does not die before the period is

completed. In a country such as Scotland, before 1938, in which specific fertility rates were not available owing to the deficiency of the information recorded at the registration of a birth, these gross reproduction rates could be obtained only indirectly. It can be shown that the same figures, apart from a common factor, are obtained by the method of regional correction factors applied to the general total fertility rates. It follows that, if either rate be expressed as a percentage of the corresponding rate for Scotland as a whole, the resulting values are identical. The close relationship between the two sets of rates may be demonstrated in the following way.

Let us denote by $S_1, S_2, \ldots S_6$, the specific fertility rates which have been selected for the purpose of indirect standardisation. (In our own investigation these were the rates estimated to hold for Scotland as a whole in 1931, but the method of indirect standardisation can be carried out with any appropriate set of standard rates.) Let f be the general fertility rate of the local area; $m_1, m_2, \ldots m_6$, the numbers of women in the various age-groups in the local area; $m \left(= \sum_{\theta=1}^{6} m_\theta\right)$, the number of women aged 15-45 in the local area; $M_1, M_2, \ldots M_6$, the numbers of women in the various age-groups in Scotland as a whole; and $M \left(= \sum_{\theta=1}^{6} M_\theta\right)$, the number of women aged

15-45 in Scotland as a whole.

To obtain the appropriate correction factor, we calculate the ratio of the general fertility rate for the whole of Scotland to the rate in the local area, on the assumption that the same specific fertility rates, namely, S_1, S_2, . . . S_6, hold for both. The factor is clearly $\frac{\frac{\sum M_\theta S_\theta}{M}}{\frac{\sum m_\theta S_\theta}{m}} = \frac{\sum M_\theta S_\theta}{\sum m_\theta S_\theta} \cdot \frac{m}{M}$.

Whence the standardised rate for the local area = $f \cdot \frac{\sum M_\theta S_\theta}{\sum m_\theta S_\theta} \cdot \frac{m}{M} = \frac{mf}{\sum m_\theta S_\theta} \cdot \frac{\sum M_\theta S_\theta}{M}$. The second factor is constant for all the areas.

The process employed by Dr Charles in estimating the gross reproduction rates may be formulated as follows. She assumes that the local specific rates are proportional to the standard rates S_1, S_2, . . . S_6, all modified by a common factor so chosen as to make the number of births calculated for the local area agree with the actual number observed. If the factor is k, then the gross fertility rate will be $k\sum S_\theta$. But k has to be chosen so that $\sum m_\theta k S_\theta$ is equal to the observed number of births, m f. Whence $k = \frac{mf}{\sum m_\theta S_\theta}$. Whence the gross fertility rate $= \frac{mf}{\sum m_\theta S_\theta} \cdot \sum S_\theta$, and the gross reproduction rate $= \frac{mf}{\sum m_\theta S_\theta} \cdot \sum S_\theta \cdot p$, where p is the ratio of female births to all births, and this is presumably approximately constant for all

districts. It is clear that both indices depend essentially on the fraction $\frac{m\ f}{\sum m_o\ S_o}$; each consists of this ratio multiplied by a factor which is constant for all areas, and therefore does not affect the relative magnitude of the local rates. This demonstrates that, if the gross reproduction rate and the standardised value of the general fertility rate are calculated by the use of the same set of standard fertility rates, essentially the same set of local values will be obtained, apart from a common factor.

It is to be observed that the fraction $\frac{m\ f}{\sum m_o\ S_o}$ is simply the observed number of births divided by the calculated number of births, and it is this ratio which determines the order of the standardised general fertility rates.

(The process of standardisation is, in practice, slightly complicated by the fact that the general fertility rates commonly employed involve the ratio of births to the number of women aged 15-45, although a small proportion of these births are born to mothers between 45 and 50, and a quite negligible proportion to mothers over 50. In standardising, we calculate the local factors employing seven, and not six, quinquennial age-groups (the group 45-50 being included) and the corresponding standard specific fertility

rates. Thus, m is not strictly $\sum m_\theta$, and the above formulae, to be strictly applicable, would require to be slightly modified. The modification involves a factor

$$\frac{\sum_{\theta=1}^{6} m_\theta}{\sum_{\theta=1}^{7} m_\theta} \Big/ \frac{\sum_{\theta=1}^{6} M_\theta}{\sum_{\theta=1}^{7} M_\theta}$$

, but as the value of

$$\frac{\sum_{\theta=1}^{6} m_\theta}{\sum_{\theta=1}^{7} m_\theta}$$

is not likely to vary much as between the various districts, it will always be very nearly equal to $\frac{\sum_{\theta=1}^{6} M_\theta}{\sum_{\theta=1}^{7} M_\theta}$, and so the correcting factor will always be approximately unity, and may be neglected.)

Dr Charles (1938) used the total rates, employing all births and all women. Our survey is concerned with legitimate rates, employing legitimate births and married women, so that the two investigations may be regarded as complementary to each other.

In a second paper Dr Charles (1939) worked out certain modifications of the gross reproduction rate which took into account the variation in the

proportion of women at different ages who were married. However, the indices she employed are different from, and not directly comparable with, our own. Another difference between Dr Charles' calculations and ours is that she used as standard rates those of Sweden, whilst we used the rates for Scotland (obtained, as explained below, by a special investigation carried out on the 1931 Census returns). This difference, however, is not an important one; as Dr Charles herself points out, the results are insensitive, over a wide range, to variations in the standard rates employed. On general grounds, however, it seemed advisable to use the rates estimated for the whole of Scotland at the period in question, as these were available.

(b) Specific Legitimate Fertility Rates, Scotland, 1931, estimated from the Census Returns.

In order to obtain estimates of specific legitimate fertility rates for Scotland (required to calculate the local area correction factors), permission was given by the Registrar-General for Scotland for the present writer to make a special count on a sample of approximately one tenth of the 1931 Census enumeration books. To ensure that the sample was a random one, every tenth book, in general, was selected, and

952 were scrutinized out of a total of 9,175. This was rather more than the ten per cent. aimed at originally, and resulted from the inclusion of a few additional books, for example, when a county was rather small. The population of the sample was 10.17 per cent. of the total population.

In general, the principle underlying the investigation was that adopted in the Registrar-General's Statistical Review of England and Wales, 1922 and 1932, to make estimates of specific legitimate fertility rates for England and Wales. Each child under one year of age was noted, and when the mother could be identified, and was married, her age also was recorded. The child's age in months was then deducted from the mother's age, to ascertain the latter at the time the child was born. Unless the child's mother could be identified in the records with reasonable certainty, the observation was rejected. Although, for this reason, about ten per cent. of the selections had to be ignored, a sample was ultimately obtained of 7,799 legitimate children under one year, distributed according to age of mother at the time of their birth. These children, being on the average six months old, were the survivors of the legitimate births at a time, on the average, six months earlier. It

was assumed that the death-rate of infants is not correlated with the mother's age, and so the distribution of the survivors, found in the manner described above, was taken as the distribution of the actual births. The number of children in each quinquennial age-group was then increased by a constant factor so that the resulting sum would equal the total number of legitimate births in 1931. Finally, specific legitimate fertility rates were computed by relating the number of children in each age-group to the corresponding number of married females, as enumerated at the 1931 Census.

The results, which were published in the Eighty-Third Annual Report, for 1937, are summarised in Table XLI. The rates for Scotland as a whole were used as standard rates to calculate factors for correcting local area general legitimate fertility rates. The table also contains a statement of the standard errors. These are calculated from the approximate formula S.E. = Rate/$\sqrt{N}$, where N is the number of observations from which the rate is derived.

TABLE XLI.

Specific Legitimate Fertility Rates, Scotland, 1931.

Age-group.	All Scotland.		Large Burghs.		Small Burghs.		Landward Areas.	
	Rate.	S.E.	Rate.	S.E.	Rate.	S.E.	Rate.	S.E.
15–	588·2	± 35·9	541·6	± 44·6	619·8	± 96·8	679·6	± 76·5
20–	386·5	± 9·3	388·9	± 12·3	397·6	± 23·9	373·6	± 17·7
25–	256·8	± 5·3	256·9	± 7·0	244·1	± 12·8	262·5	± 10·3
30–	166·1	± 3·9	166·5	± 5·1	134·3	± 8·5	183·7	± 7·8
35–	107·3	± 3·1	108·0	± 4·2	101·4	± 7·5	108·9	± 6·0
40–	35·9	± 1·9	34·1	± 2·5	30·6	± 4·2	42·6	± 3·9
45–	4·3	± 0·7	4·1	± 0·9	3·7	± 1·5	4·8	± 1·3

It is interesting to record that, in the sample taken, one married woman was found who had a child when 48 years old, one when 49, and one when 50. Special care was taken, in the case of these mothers of advanced years, to verify their relationship with the child observed.

(c) Standardisation of General Legitimate Fertility Rates: Data and Results.

Amongst the divisions of Scotland to be employed are clearly the Large Burghs, the Small Burghs, and the Landward Areas, to which reference has already so frequently been made. For further subdivision the counties are obviously the most suitable units, as the

available data are already, in part, arranged according to these administrative areas. We have then, in all, 90 districts, namely, 33 Landward Areas, 33 groups of Small Burghs, and 24 Large Burghs.

Errors resulting from the use of too small numbers have been reduced by the use of a ten-year period, namely, the decade 1926-35. The total legitimate births for these ten years were calculated from official sources (the Annual Reports concerned) for the 90 districts separately. The distributions of married women used were those given by the Census of 1931. For our purpose it was desirable to employ, not the numbers as enumerated, but the numbers permanently resident in the district. A substantial discrepancy between this number and the figure enumerated is occasionally found. In Bute Small Burghs (Rothesay and Millport), for example, the enumerated married women aged 15-45 exceeded the resident by 34.7%. The resident population of married women arranged according to age, for the various districts, has not been published, but, by the courtesy of the Registrar-General, we have been enabled to calculate them from data available in the Register House. The calculation of the actual number of births in the districts during the decennial period also involved a number of minor adjustments, most of

which were occasioned by the changes in classification of Burghs which were introduced in 1931. The results are presented on the basis of the local areas as these were in that year.

The observed and standardised general legitimate fertility rates of the various counties of Scotland are shown in Tables XLII and XLIII respectively. The corresponding rates for the 24 Large Burghs are presented in Table XLIV. Each table contains not only the general fertility rate, but also its value in terms of Scotland as 100, and its standard error. The geographical distribution of the standardised rates for the Landward Areas and the Small Burghs is represented pictorially in Diagrams 22 and 23.

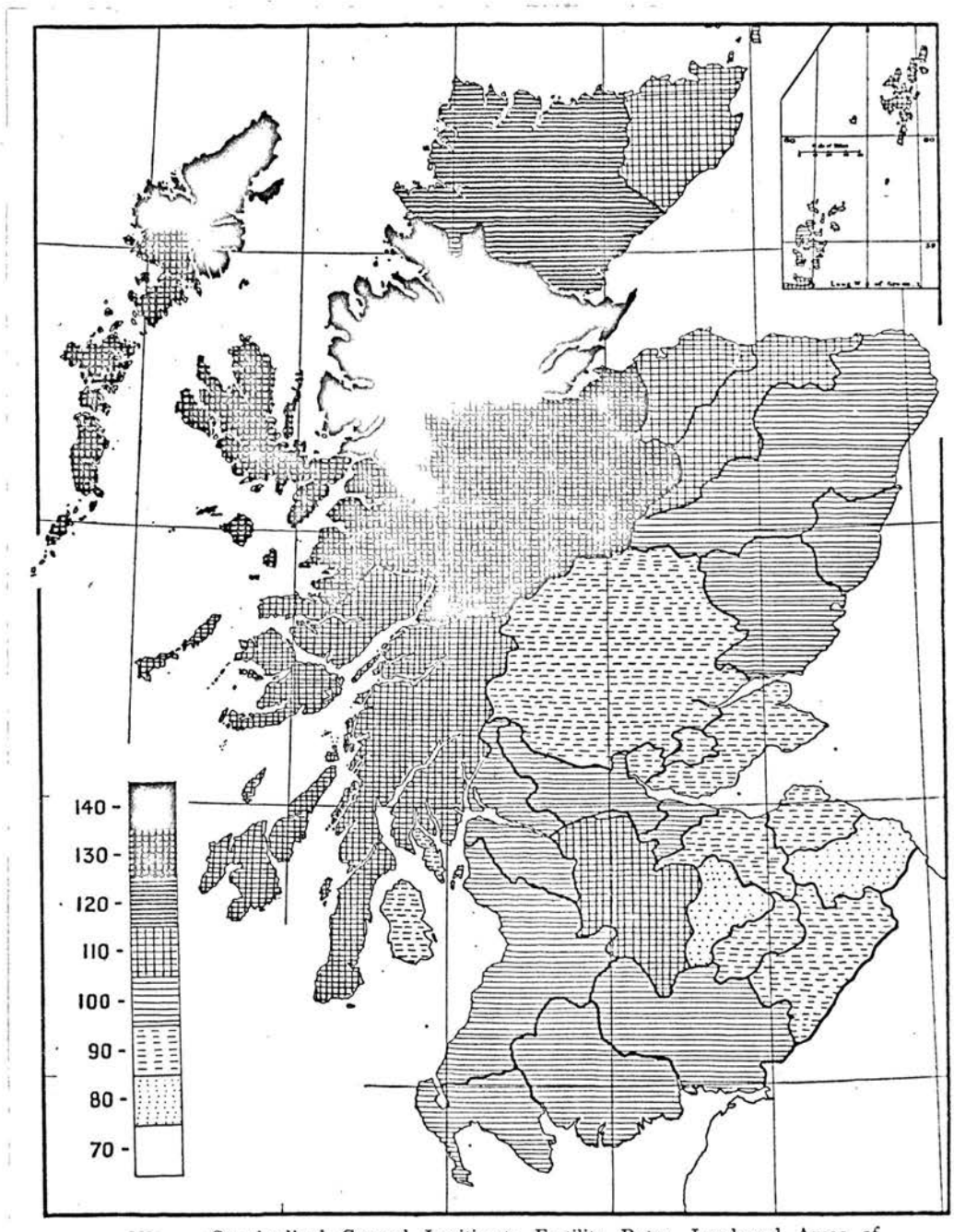
It will be seen that the effect of standardisation is, in some instances, considerable. Thus, in the case of Small Burghs, Argyll, which in the unstandardised list is seventh in rank with a value of 171.5, rises to second place (value 188); Ross and Cromarty (unstandardised 155.6, standardised 174) rises from eighteenth to eighth place; whilst Orkney (unstandardised 138.3, standardised 154) rises from twenty-eighth to twenty-second place. Similar changes are shown by the Landward Areas: Argyll, for instance, rises from twenty-first to tenth place. In the case

TABLE XLII.

OBSERVED GENERAL LEGITIMATE FERTILITY RATES, COUNTIES OF SCOTLAND, 1926–1935.

County.	Small Burghs.				Landward Areas.			
	Rate.	S.E.	Relative Rate: Scotland = 100.	Order.	Rate.	S.E.	Relative Rate: Scotland = 100.	Order.
Aggregate .	157·3	± 0·5	92·6		179·9	± 0·4	105·9	
Aberdeen .	144·3	± 1·8	84·9	25	190·8	± 1·4	112·3	8
Angus . .	140·8	± 2·0	82·9	26	167·1	± 2·2	98·3	22
Argyll . .	171·5	± 3·1	100·9	7	168·1	± 2·4	98·9	21
Ayr . .	157·5	± 1·3	92·7	16	182·8	± 1·2	107·6	12
Banff . .	177·1	± 2·4	104·2	3	198·4	± 3·0	116·8	4
Berwick .	128·3	± 4·5	75·5	32	138·8	± 2·6	81·7	32
Bute . .	155·4	± 4·4	91·5	19	144·6	± 5·3	85·1	29
Caithness .	203·4	± 4·5	119·7	1	187·3	± 4·0	110·2	10
Clackmannan	148·9	± 2·5	87·6	22	157·8	± 3·7	92·9	25
Dunbarton .	159·7	± 2·5	94·0	11	171·3	± 1·8	100·8	17
Dumfries .	148·8	± 3·3	87·6	23	169·7	± 2·0	99·9	20
East Lothian .	172·8	± 2·8	101·7	5	166·0	± 2·5	97·7	24
Fife . .	145·7	± 1·2	85·7	24	171·2	± 1·2	100·8	18
Inverness .	184·1	± 7·7	108·3	2	205·3	± 2·3	120·8	3
Kincardine .	155·1	± 4·7	91·3	20	186·8	± 3·2	109·9	11
Kinross .	171·7	± 8·5	101·1	6	153·7	± 5·9	90·5	26
Kirkcudbright	158·6	± 4·1	93·3	13	178·9	± 3·1	105·3	15
Lanark .	156·9	± 4·6	92·3	17	192·0	± 0·8	113·0	6
Midlothian .	158·8	± 2·0	93·5	12	170·0	± 1·8	100·1	19
Moray .	158·1	± 2·8	93·0	14	193·2	± 3·3	113·7	5
Nairn . .	169·5	± 7·1	99·8	8	210·2	± 7·8	123·7	2
Orkney .	138·3	± 5·5	81·4	28	171·4	± 3·5	100·9	16
Peebles .	133·4	± 4·1	78·5	30	134·5	± 4·6	79·2	33
Perth . .	152·6	± 2·8	89·8	21	152·9	± 1·7	90·0	27
Renfrew .	166·5	± 1·7	98·0	9	151·6	± 1·7	89·2	28
Ross and Cromarty	155·6	± 4·1	91·6	18	215·0	± 2·5	126·5	1
Roxburgh .	136·2	± 2·3	80·2	29	143·3	± 2·8	84·3	31
Selkirk .	120·0	± 2·5	70·6	33	143·7	± 6·2	84·6	30
Stirling .	163·7	± 2·3	96·3	10	181·9	± 1·5	107·1	13
Sutherland .	138·7	± 15·0	81·6	27	191·0	± 4·2	112·4	7
West Lothian.	174·0	± 2·2	102·4	4	189·6	± 1·9	111·6	9
Wigtown .	157·7	± 3·8	92·8	15	181·3	± 3·2	106·7	14
Zetland .	129·5	± 6·0	76·2	31	166·5	± 3·7	98·0	23

of the Large Burghs, the change of order on standardisation is not so marked. It is of interest to notice that the four Border counties, Berwick, Roxburgh,



Standardised General Legitimate Fertility Rates, Landward Areas of Scotland, 1926–1935. (The general legitimate fertility rate of Scotland, 1926–1935, is taken as 100.)

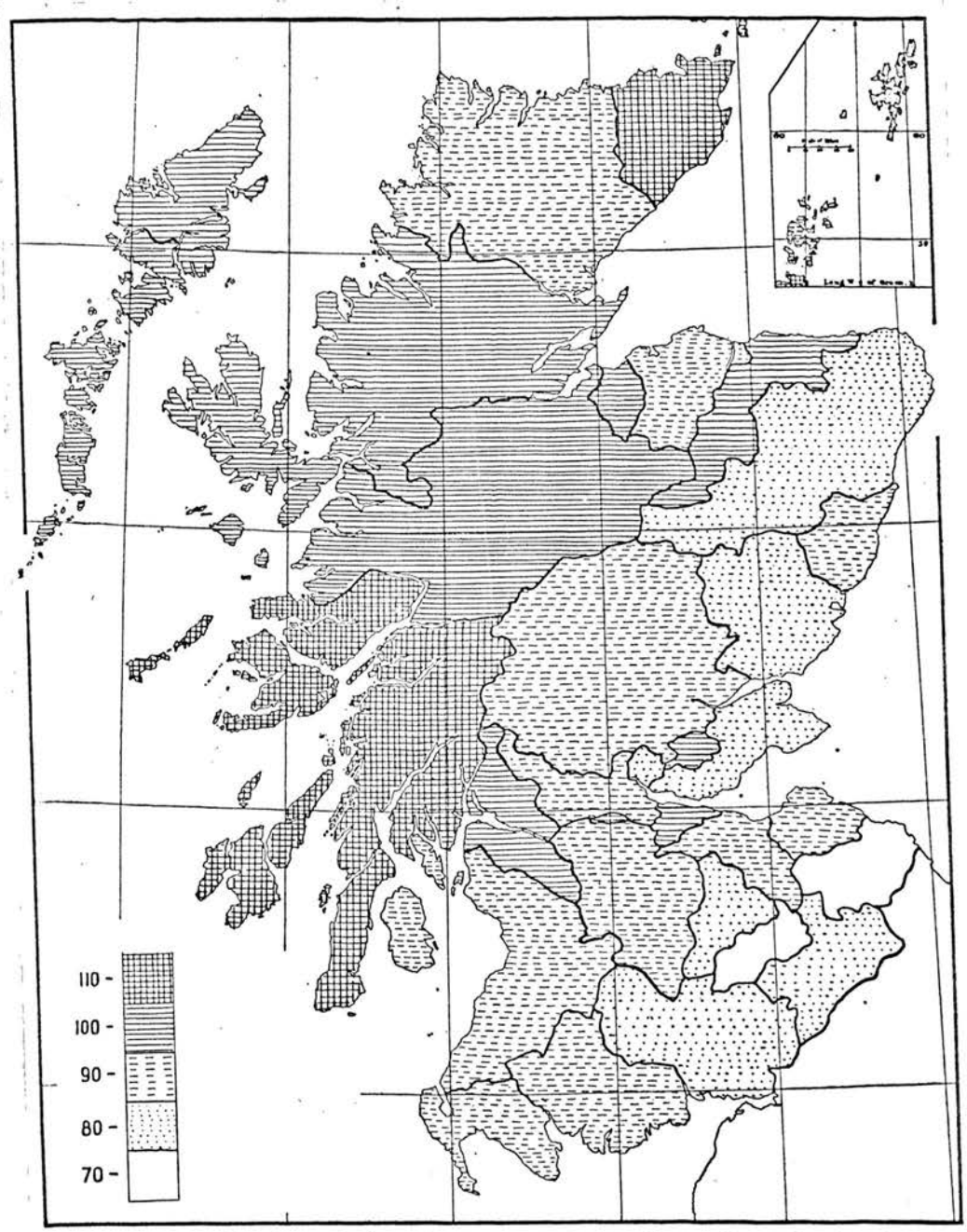
Diagram 22.

TABLE XLIII.

STANDARDISED GENERAL LEGITIMATE FERTILITY RATES, COUNTIES OF SCOTLAND, 1926–1935.

County.	Small Burghs.				Landward Areas.			
	Rate.	S.E.	Relative Rate: Scotland = 100.	Order.	Rate.	S.E.	Relative Rate: Scotland = 100.	Order.
Aggregate . .	160	± 0·5	94·2		182	± 0·4	107·2	
Aberdeen . .	138	± 1·8	81·3	30	183	± 1·4	107·7	13
Angus . .	149	± 2·2	87·6	27	173	± 2·2	101·8	19
Argyll . .	188	± 3·3	110·4	2	188	± 2·7	110·8	10
Ayr . . .	160	± 1·3	93·9	17	178	± 1·2	104·7	17
Banff . .	177	± 2·4	104·1	6	199	± 3·0	117·2	5
Berwick . .	133	± 4·7	78·3	32	147	± 2·8	86·5	33
Bute . . .	165	± 4·7	97·0	13	160	± 5·8	93·9	28
Caithness . .	194	± 4·3	114·2	1	194	± 4·2	114·3	7
Clackmannan .	150	± 2·6	88·5	26	157	± 3·7	92·5	29
Dunbarton . .	170	± 2·6	100·0	10	179	± 1·9	105·4	16
Dumfries . .	153	± 3·4	89·9	23	173	± 2·0	101·6	20
East Lothian .	169	± 2·7	99·6	11	166	± 2·5	97·7	26
Fife . . .	145	± 1·2	85·4	28	168	± 1·2	98·6	24
Inverness . .	186	± 7·7	109·5	3	235	± 2·7	138·3	2
Kincardine .	157	± 4·8	92·4	21	186	± 3·2	109·6	11
Kinross . .	178	± 8·8	104·6	5	168	± 6·5	99·0	25
Kirkcudbright .	160	± 4·1	94·3	18	181	± 3·1	106·6	14
Lanark . .	158	± 4·6	92·7	20	191	± 0·8	112·3	9
Midlothian .	162	± 2·0	95·2	15	169	± 1·8	99·6	23
Moray . .	163	± 2·9	95·9	14	193	± 3·3	113·6	8
Nairn . .	180	± 7·5	105·7	4	223	± 8·3	131·4	3
Orkney . .	154	± 6·1	90·8	22	172	± 3·5	101·1	21
Peebles . .	136	± 4·2	80·2	31	150	± 5·1	88·4	32
Perth . .	160	± 2·9	93·9	19	161	± 1·8	94·7	27
Renfrew . .	175	± 1·8	103·0	7	171	± 2·0	100·5	22
Ross and Cromarty	174	± 4·6	102·2	8	255	± 2·9	149·9	1
Roxburgh . .	141	± 2·4	83·1	29	154	± 3·0	90·8	31
Selkirk . .	128	± 2·7	75·6	33	157	± 6·7	92·5	30
Stirling . .	162	± 2·3	95·3	16	176	± 1·4	103·7	18
Sutherland .	168	± 18·1	98·9	12	205	± 4·5	120·6	4
West Lothian .	172	± 2·1	101·0	9	185	± 1·9	108·8	12
Wigtown . .	153	± 3·7	90·2	24	181	± 3·2	106·7	15
Zetland . .	152	± 7·1	89·4	25	196	± 4·3	115·6	6

Peebles, and Selkirk, are at the foot of all the tables, Landward or Small Burghs, standardised or unstandardised.



Standardised General Legitimate Fertility Rates, Small Burghs of Scotland, 1926–1935. (The general legitimate fertility rate of Scotland, 1926–1935, is taken as 100.)

Diagram 23.

TABLE XLIV.

OBSERVED AND STANDARDISED GENERAL LEGITIMATE FERTILITY RATES, LARGE BURGHS OF SCOTLAND, 1926–1935.

	Observed.				Standardised.			
Large Burgh.	Rate.	S.E.	Relative Rate: Scotland = 100.	Order.	Rate.	S.E.	Relative Rate: Scotland = 100.	Order.
Aggregate .	168·2	± 0·2	99·0		167	± 0·2	98·0	
Glasgow . .	173·9	± 0·4	102·3	8	172	± 0·4	101·4	8
Edinburgh .	146·8	± 0·6	86·4	22	149	± 0·6	87·5	21
Dundee . .	166·5	± 0·9	98·0	12	164	± 0·9	96·3	14
Aberdeen .	159·0	± 0·9	93·6	17	153	± 0·9	90·2	18
Paisley . .	172·2	± 1·3	101·3	9	172	± 1·3	101·5	9
Greenock .	195·5	± 1·5	115·1	5	189	± 1·5	111·2	5
Motherwell and Wishaw .	183·6	± 1·6	108·1	7	179	± 1·5	105·6	7
Clydebank .	168·9	± 1·8	99·4	11	170	± 1·8	100·0	10
Kirkcaldy .	148·7	± 1·7	87·5	21	149	± 1·7	87·9	22
Coatbridge .	212·1	± 2·1	124·8	2	204	± 2·0	119·9	2
Kilmarnock .	160·4	± 1·9	94·4	16	156	± 1·9	92·1	16
Hamilton .	199·7	± 2·2	117·5	3	187	± 2·0	110·1	6
Ayr . .	166·3	± 2·0	97·9	13	160	± 2·0	94·3	15
Falkirk . .	159·0	± 1·9	93·6	18	152	± 1·9	89·2	20
Dunfermline .	139·3	± 1·8	82·0	24	147	± 1·9	86·3	24
Perth . .	145·0	± 2·0	85·3	23	148	± 2·0	87·3	23
Airdrie . .	197·3	± 2·6	116·1	4	192	± 2·5	112·9	3
Rutherglen .	150·9	± 2·4	88·8	20	154	± 2·4	90·6	17
Dumfries .	155·7	± 2·5	91·6	19	152	± 2·4	89·2	19
Stirling . .	172·1	± 2·7	101·3	10	165	± 2·5	96·9	12
Inverness . .	163·3	± 2·7	96·1	14	165	± 2·7	97·1	11
Dumbarton .	183·7	± 2·9	108·1	6	189	± 2·9	111·0	4
Port-Glasgow .	220·3	± 3·2	129·7	1	211	± 3·1	124·4	1
Arbroath . .	163·2	± 3·1	96·0	15	164	± 3·1	96·7	13

When the rates are expressed in terms of that of Scotland as a whole, there is a difference, between standardised and unstandardised, of 5-10% in 8 out of the 33 counties, in the case of Small Burghs, and of over 10% in 3. For the Landward Areas, the corresponding figures are 7 and 5 respectively. Two Large

Burghs show changes of over 5%.

The standardised rates for the aggregates of Small Burghs, Large Burghs, and Landward Areas are 160, 167, and 182 respectively, that of the whole of Scotland being 169.9. The lowest rates are found in the Small Burghs of Selkirk (128) and Berwick (133), whilst the highest are in the Landward Areas of Ross and Cromarty (255) and Inverness (235). The Large Burghs also exhibit a very considerable range, from Dunfermline with 147 to Port-Glasgow with 211.

Two main points emerge from Tables XLII and XLIII (Diagrams 22 and 23). First, fertility is greater in the Landward districts than in the Small Burghs, not only throughout Scotland as a whole, but also in almost every single county. Where the order is disturbed, as in the case of East Lothian, the total number of births involved is not large enough for the results to be significant. Secondly, the Landward Areas show a fairly regular sequence in their fertilities. The highest value is found in Ross and Cromarty. On moving northwards, or southwards and eastwards, from this point, we observe progressively lower values. Thus, the lowest fertilities are in the south and east, in Roxburgh, Peebles, Selkirk, and Berwick. A parallel tendency is noticeable in the case of the Small Burghs, but the regularity is not so great. The

Large Burghs are not sufficiently widely distributed throughout Scotland to enable any analogous conclusions to be drawn. But it is of interest to note that the ten Burghs with the largest fertility rates are all at the western end of the industrial belt, whilst the seven of lowest fertility are either on the eastern seaboard or in the extreme south (Dumfries).

The case of Ross and Cromarty (Landward Area) is of special interest. The fertility rate, either crude or standardised, is the highest of all, and it is also peculiar in that the effect of the correction is greater than for any other. This large correction is a consequence of the fact that the average age of the married women in this county is abnormally high, which, in turn, is, at least partly, due to the circumstance that the average age of marriage is unusually great, a peculiarity pointed out by Dr Charles in her discussion of Scottish total fertility. Now this high average age at marriage, which is characteristic of all the crofting counties, means that women of age, say 35, will, on the average, have been married a considerably shorter time than their contemporaries elsewhere in Scotland. The fertility rates for Swedish women reproduced in Table IX (p. 52), classified in respect both of age and duration of marriage, show that, up to age 35, the duration of

marriage is even more important than age. A consequence of the great importance of duration of marriage is that, other things being equal, these Ross and Cromarty women, simply because of their later marriages, would appear to be unusually fertile. This would be the case even though their real fertility, the fertility rates considered as functions of both age and duration of marriage, was no greater than that of the rest of Scotland. This does not, of course, alter the fact that the age specific fertility rates of these women are abnormally high, but it does suggest an explanation for this peculiarity.

This example illustrates the disadvantage of analysing fertility in terms of the age of women alone, and emphasises the importance of the official statistics being so presented that the effect of duration of marriage can also be taken into account. At the present time, as far as we know, this can be done only in the case of the special Swedish statistics referred to above.

(d) Discussion.

Amongst the more noteworthy features revealed by the present investigation is the relatively low fertility of the Small Burghs as compared with the Landward Areas, not only in Scotland as a whole, but also

in the great majority of the counties taken separately. Of the four cities, Glasgow and Dundee have fertilities of intermediate value, but Edinburgh and Aberdeen are less fertile than the average Small Burgh. The other Large Burghs show considerable variation, those in the west being, in general, much more fertile than those in the east. There is no striking deficiency in the fertility of the large towns as compared with that of the rural areas, such as is a marked characteristic of many industrialized countries - for example, the United States or Germany. In this respect Scotland resembles England and Wales. There is thus little evidence that the decrease of fertility in Scotland is in any direct way to be associated with the progressive urbanisation to which the country has been subjected. Indeed, it would seem to be a reasonable expectation that, if the large cities and other Large Burghs were replaced by numerous Small Burghs of semi-rural aspect, the fertility would be even lower than it is at the present time.

The results presented in this study may be regarded as complementary to those of Dr Charles. This author has concentrated attention on total fertility, and has made it clear that, in relation to this, the degree of nuptiality is a very important factor,

fertility being low when there is a large percentage of unmarried women in the community. This would seem to be an important factor in reducing the total fertility in textile manufacturing districts, where many women are employed in mills, and where, in consequence, there is an unusually high proportion of single women. It is interesting to notice that, in the case of legitimate fertility, this is low in some textile districts, such as Selkirk, but high in others - for example, Paisley.

The investigation carried out in this section makes it clear that the standardisation of the general legitimate fertility rates does not introduce any very profound change in the picture provided by the unstandardised rates. In particular, the contrast between the Highland and Border counties referred to in section 2 (c) remains an outstanding one; indeed the effect of standardisation is definitely to magnify the difference in their fertility rates. The standardised rates of the various divisions show no more relation to the degree of urbanisation than do the crude rates. It seems probable that the picture of the trends of fertility in the various regions, as given in sections 2 (b) and 2 (c) on the basis of the unstandardised general fertility rates, would not be substantially modified if all these rates had been

standardised in respect of the age distribution of the mothers. These results may, therefore, be taken as a reliable representation of the course of fertility in the various urban and rural divisions of Scotland during the past eighty years.

CHAPTER VI.

SUMMARY and CONCLUSIONS.

The official registration of births, deaths, and marriages in Scotland was commenced in 1855. During the early years a slight rise in the birth-rate took place, but this is attributable to the defective registration during the initial period following its introduction. The birth-rate then remained at approximately 35 per 1000 up to about 1880. From then onwards, like the birth-rate in many other countries, it declined more or less steadily until, in 1936-40, its value was only 17.6. There are reasons for believing that before the days of official registration the Scottish birth-rate may have continued for a century or more in the neighbourhood of 35 per 1000.

An indication has been given of the probable trend of the death-rate in Scotland in pre-registration days. The method of reconstructing these early rates is based on somewhat speculative assumptions, but it seems certain that the death-rate began to decline much earlier than the birth-rate. It is probable that a general fall in mortality took place in Scotland from about 1750 to 1820, and that a period of relative constancy preceded the modern fall which set in about 1875.

Against this background a study has been made of various aspects of mortality and fertility in the urban and rural divisions of Scotland, since 1855.

In the decades immediately following the introduction of official registration (in 1855) the crude death-rates were much higher in the urban than in the rural divisions, and considerably higher in the larger than in the smaller towns. During most of the period which has been studied the death-rate has been falling, and the fall has been relatively steeper in the towns than in the country, so that the gap is now much less than it was formerly. In 1936-38, however, an appreciable gap still remained between the level of mortality in the Large Burghs and that in the Landward Areas. Standardised rates are given from 1911 onwards, and it appears that the effect of standardisation is to increase the difference between town and country, in consequence of the town populations being, in general, younger than those of the country.

Tables of specific death-rates are given for the "Town" and "Country" districts of Scotland for various calendar periods from 1871 onwards. When these were analysed by Kermack, McKendrick, and McKinlay's method, it was found that the Diagonal Law, previously

demonstrated by these writers for the population of Scotland as a whole, as well as for certain other European countries, holds for these two subdivisions of the community.

Reasons have been given for the view that the generation mortality coefficients may be taken as a rough measure of the "healthiness" of the environmental conditions which obtained during the childhood of the generation to which they refer. This affords a basis for the comparison of the healthiness of the environment of town and country at different periods in the past.

Whereas in the earlier half of the nineteenth century the ratio of the generation mortality coefficient in the country to that in the town was in the neighbourhood of 0.6, indicating that the health conditions in the country might be said to be almost twice as good as in the towns, in 1931 it had risen to almost unity, showing that by that time the town had almost if not quite made up on the country. This gives a verdict more favourable to the town than would be arrived at by an inspection of the crude or standardised death-rates. During this period both town and country conditions showed remarkable improvements, which are reflected in falls of the respective generation mortality coefficients - from over 12 in the

country, and from about 20 in the town, in 1841, to a common level of about 4.7 in 1921.

The essential vagueness of the conception of the healthiness of an environment has been emphasized. It is necessary, consequently, not to attach too great importance to the exact numerical results, but the conclusion seems justified that, broadly speaking, the urban regions of Scotland are now almost if not quite as healthy, especially for the younger age-groups (excluding infants), as the rural areas.

The infantile death-rates of the various groups were compared with a view to ascertaining to what extent they confirmed the results found by means of the generation mortality coefficients. Infantile mortality in the Principal Towns or Larger Burghs has always greatly exceeded that of the country, and has always been higher in the larger than in the smaller towns.

A significant fall in infant mortality did not set in till about 1900, that is, about a quarter of a century after improvement in general mortality had begun, and there is evidence that a definite improvement in the infantile death-rate of the rural areas did not take place till fully a decade later than in the towns.

The percentage ratio of the infantile death-rate in the country to that in the town (using for this comparison the largest type of town or burgh) has slowly increased from about 60 in 1881-85 to 77 in 1936-40.

At first sight the trend of infantile mortality does not conform to the conclusions deduced from a study of the generation mortality coefficients. It is suggested, however, that the health of infants during the first year of life may depend not so much on their general environment, but rather on the health of the mother. This suggestion affords a ready explanation of the facts that (1) the onset in the fall in infant mortality did not occur till about a generation after the fall in general mortality had set in, (2) that the country infant mortality started to fall fully a decade later than that of the town (just as the country generation mortality coefficient started to fall about a decade later than the town generation mortality coefficient), and (3) that the ratio of country to town infant mortality is still well below unity.

A detailed survey has been made of the cancer mortality statistics for Scotland during the period from 1931 to 1937 inclusive. In order to obtain

evidence as to what extent the urban excess in cancer mortality is real, the analysis was carried out in respect of both location of tumour and geographical region.

Of the various locations, the greatest urban excess is shown by cancer of the respiratory tract; this is considered to be largely, though probably not entirely, due to better diagnosis and more accurate certification of deaths in the cities. Next come the buccal cavity and uterus; in both these locations certification is likely to be relatively accurate, so that a real excess would seem here to be present. The other accessible locations, the skin and the female breast, do not show significant urban excesses, but the numbers are small, and the existence of a real urban excess is not excluded. The results are in general agreement with those of the English experience 1911-20.

Further analysis of the data presented by Russell for Scotland, 1923-8, reveals an excess in the industrial counties of deaths for cancer of the buccal cavity, and perhaps a smaller one for cancer of the female breast. These data are, therefore, not inconsistent with our findings.

As compared with the period 1921-30, the figures for 1931-7 demonstrate, for ages 25-65, a marked

improvement in cancer of the buccal cavity and uterus. A recorded fall in cancer of the digestive organs may, in part, be due to more accurate certification in respect of the primary location. The failure of mortality from breast cancer to fall may be due to the same cause. The large increase in lung cancer is almost certainly due, in part, to better diagnosis. For all sites together, the cancer mortality between ages 25 and 65 remained constant for men, and fell by 8% in the case of women. The standardised rate for all ages and both sexes combined increased by 1.3%, a rise which is 2.2 times its standard error.

The urban excess cannot be entirely explained as due to incomplete certification in the rural areas. The implied effect of social and industrial environment in stimulating tumour growth is in harmony with the known facts regarding occupational and social cancer, and emphasizes the importance which the control of adverse environmental factors may have in the reduction of cancer incidence.

Whereas the crude birth-rate in the country has always been lower than that of the Principal Towns (or Larger Burghs), the reverse holds good in the case of the general total and general legitimate fertility rates. These have always been higher in the country.

The position of the intermediate types of smaller towns and burghs has varied, but it is noteworthy that during the last twenty years fertility in the Smaller Burghs has been definitely lowest, whether measured by the crude birth-rate, the general total fertility rate, or the general legitimate fertility rate.

A somewhat unexpected feature of fertility in Scotland is that the decline started almost simultaneously in the various urban and rural divisions of the country, with one major exception which we shall refer to later.

Not only did the fall begin almost simultaneously in the various geographical divisions, but the curves representing the rates have followed very nearly parallel courses, throughout the whole period.

A comparison of the fertility experience of Sutherland, Ross and Cromarty, Inverness, and Nairn on the one hand, and Peebles, Selkirk, Roxburgh, and Berwick on the other, reveals a major departure from the general rule that fertility started to decline simultaneously in the various urban and rural districts, and that the rate of fall has been uniform throughout Scotland. The rates for these two groups were originally at about the same level, but the Border rate began to fall rather earlier, and decreased with

such rapidity that in 1937-39 it was only two-thirds of the Highland rate. A satisfactory explanation of this remarkable difference has not been found, and calls for further investigation.

The general legitimate fertility rates for three of the four chief cities started to decline about the same time, but the beginning of the fall in Aberdeen was delayed about twenty years. After this delay, the decline proceeded at about the same rate as in the other three cities. Throughout most of the period we have studied the Edinburgh rate has been lowest.

A special investigation has been carried out on the 1931 Census returns in order to obtain estimates of the specific legitimate fertility rates for Scotland at that date.

General legitimate fertility rates, standardised indirectly by means of these specific rates, were computed for the Landward Areas and groups of Small Burghs in each county of Scotland, and also for the Large Burghs separately, for the decade 1926-35.

In general, the Landward Areas show the greatest legitimate fertility, and the Small Burghs the least, whilst the Large Burghs are intermediate. In the Landward Areas legitimate fertility is greatest in Ross and Cromarty, and decreases fairly regularly

southwards and eastwards, as well as to the north. A somewhat parallel trend is observed for the Small Burghs, though, in this case, the results are somewhat less regular. The lowest fertilities are found in the Small Burghs to the south-east, e.g., in Berwickshire.

It is evident from these results that fertility in the various areas in Scotland does not depend to any great extent on the degree of urbanization. Nor does the fall in fertility appear to have proceeded in the towns with any greater rapidity, or at an earlier date, than in the more rural areas. The greatest contrast encountered is actually between the two very similar Highland and Border groups of counties, and the factors which have caused such local differences must be sought for in particular features of the social life of the community. In Scotland, urbanization in itself does not appear to have resulted in outstandingly low fertility. For every index used, the Large Burghs are at present more fertile than the Small Burghs, and it is the latter type of community rather than the large towns which would appear particularly conducive to a low rate of reproduction.

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APPENDIX.

TABLE A.

The Population of Scotland at various Times from 1250 to 1939.

Year	Population	Source
1250	600,000	Sinclair (1826, pp. 148-9)
1707	1,048,000	Parliamentary Reports (see Sinclair, 1826, pp. 148-9)
1755	1,265,380	Webster
1795	1,526,492	Sinclair (1798, Vol. 20, p.621)
1801	1,608,420	Census
1811	1,805,864	"
1821	2,091,521	"
1831	2,364,386	"
1841	2,620,184	"
1851	2,888,742	"
1861	3,062,294	"
1871	3,360,018	"
1881	3,735,573	"
1891	4,025,647	"
1901	4,472,103	"
1911	4,760,904	"
1921	4,882,497	"
1931	4,842,980	"
1939	5,006,700	Eighty-Fifth Annual Report of the Registrar-General for Scotland, 1939.

TABLE B.

The Population of certain Principal Towns and Larger (or Large) Burghs of Scotland, 1861 to 1939.

	Glasgow	Edinburgh	Dundee	Aberdeen	Paisley	Greenock	Leith	Perth
1861	395,503 12.9	170,444 5.6	91,664 3.0	73,900 2.4	47,427 1.5	43,894 1.4	36,029 1.2	25,293 0.8
1871	477,732 14.2	201,052 6.0	120,724 3.6	88,181 2.6	48,257 1.4	59,794 1.8	46,434 1.4	26,382 0.8
1881	511,415 13.7	228,373 6.1	142,455 3.8	105,076 2.8	55,638 1.5	69,238 1.9	61,188 1.6	29,756 0.8
1891	565,839 14.1	261,225 6.5	155,675 3.9	121,895 3.0	66,425 1.7	63,512 1.6	69,885 1.7	30,768 0.8
1901	761,709 17.0	316,837 7.1	161,173 3.6	153,503 3.4	79,363 1.8	68,142 1.5	77,439 1.7	32,873 0.7
1911	781,922 16.4	319,247 6.7	164,466 3.5	163,567 3.4	84,281 1.8	75,028 1.6	80,277 1.7	35,772 0.8
1921	1,034,174 21.2	420,264 8.6	168,315 3.4	158,963 3.3	84,837 1.7	81,123 1.7	Incorporated with Edinburgh (see p. 24)	33,208 0.7
1931	1,088,461 22.5	439,010 9.1	175,585 3.6	167,258 3.5	86,445 1.8	78,949 1.6		34,807 0.7
1939	1,128,473 22.5	471,897 9.4	178,013 3.6	179,628 3.6	92,072 1.8	81,366 1.6		36,675 0.7

The figure beneath the population of each town is the percentage ratio of the population to that of the entire country.

TABLE C.

A List of all the Principal Towns and Larger (or Large) Burghs of Scotland, at various Periods, with their Population at the 1931 Census.

8 Principal Towns, 1871	15 Principal Towns, 1910	18 Larger Burghs, 1911-12	16 Larger Burghs, 1913-20	16 Larger Burghs, 1921-30	24 Large Burghs, 1931	Census Population 1931
Glasgow	Glasgow	Glasgow	Glasgow	Glasgow	Glasgow	1,088,461
Edinburgh	Edinburgh	Edinburgh	Edinburgh	Edinburgh	Edinburgh	439,010
Dundee	Dundee	Dundee	Dundee	Dundee	Dundee	175,585
Aberdeen	Aberdeen	Aberdeen	Aberdeen	Aberdeen	Aberdeen	167,258
Paisley	Paisley	Paisley	Paisley	Paisley	Paisley	86,445
Greenock	Greenock	Greenock	Greenock	Greenock	Greenock	78,949
Leith	Leith	Leith	Leith	a	-	-
Perth	Perth	Perth	Perth	Perth	Perth	34,807
	Partick	Partick	a	-	-	-
	Govan	Govan	a	-	-	-
	Kilmarnock	Kilmarnock	Kilmarnock	Kilmarnock	Kilmarnock	38,100
	Coatbridge	Coatbridge	Coatbridge	Coatbridge	Coatbridge	43,056
	Hamilton	Hamilton	Hamilton	Hamilton	Hamilton	37,862
	Motherwell	Motherwell	Motherwell	Motherwell & Wishaw	Motherwell & Wishaw	64,710
	Kirkcaldy	Kirkcaldy	Kirkcaldy	Kirkcaldy	Kirkcaldy	43,874
		Falkirk	Falkirk	Falkirk	Falkirk	36,566
		Clydebank	Clydebank	Clydebank	Clydebank	46,952
		Ayr	Ayr	Ayr	Ayr	36,783
				Dunfermline	Dunfermline	35,058
					Airdrie	25,954
					Arbroath	17,635
					Dumbarton	21,546
					Dumfries	22,795
					Inverness	22,583
					Port-Glasgow	19,581
					Rutherglen	25,157
					Stirling	22,593

a. See p. 24.